A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND CLOSED REDUCTION IN INTERNAL FIXATION OF PROXIMAL TIBIA FRACTURES"

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CERTIFICATE

This is to certify that this dissertation titled **"A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND CLOSED REDUCTION IN INTERNAL FIXATION OF PROXIMAL TIBIA FRACTURES"** is a bonafide record of work done by **DR. VINOTH.S ,** during the period of his Post graduate study from May 2013 to April 2016 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfillment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2016.

Prof. R.VIMALA

Dean,

Madras Medical College & Rajiv Gandhi Government General Hospital,

Chennai - 600 003.

Prof. N.DEEN MUHAMMAD ISMAIL

Director I/C,

Institute of Orthopaedics and Traumatology,

Madras Medical College & Rajiv Gandhi Government General Hospital,

Chennai - 600003.

DECLARATION

I declare that the dissertation entitled **"A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND CLOSED REDUCTION IN INTERNAL FIXATION OF PROXIMAL TIBIA FRACTURES"** *submitted by me for the degree of M.S is the record work carried out by me during the academic period of 2013 to 2016 under the guidance of* ***Prof.A.PANDIASELVAN*** **M.S.Ortho., D.Ortho.,** *Institute of Orthopaedics and Traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2016.*

Place: *Chennai* **Signature of the Candidate**

Date: **(Dr. Vinoth.S)**

Signature of the Guide
Prof.*A.PANDIASELVAN* M.S.Ortho., D.Ortho.,,
Institute of Orthopaedics and Traumatology,
Madras Medical College, Chennai.

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CONTENTS

INTRODUCTION

Fractures of the tibial plateau usually result from high energy trauma. Motor vehicle accidents seem to be the predominant cause worldwide. Knee is the major weight bearing joint of the body. Fractures of the tibial plateau change the knee kinematics alter joint stability and cause joint incongruity. Fractures range from simple lateral condyle fracture to severely comminuted metaphyseal fractures.

Less severe types and undisplaced fractures can be treated operatively or non-operatively. Good results have been reported by numerous authors by either method.

For more severe type fractures there is consensus regarding operative management. Various surgical modalities like open reduction internal fixation with cannulated screw , AO/ASIF Buttress plate (T/L), Proximal tibial locking plate have been practised.

In independent analysis high energy tibial plateau fracture fixation has been associated with high rate of complications and poor functional outcome due to precarious skin and soft tissue condition.. So the recent trend is surgical fixation of such high energy (type V and VI Schatzker) tibial plateau fracture by

minimally invasive techniques. This can be achieved through indirect reduction of fracture by ligamentotaxis which minimizes surgical trauma area.

Tibial plateau fractures are serious injuries that commonly result in functional impairment. The objective in treating displaced fractures is to restore the articular surface anatomy, stable internal fixation to obtain a painless and stable knee joint with normal range of movements.

Design of study : Retrospective and prospective

Duration of study : July 2014 to September 2015

AIM OF THE STUDY

To compare the functional and radiological outcome of proximal tibia fractures treated with internal fixation by methods of open reduction and closed reduction.

OBJECTIVES

1. Pre-operative assessment to evaluate the age wise distribution of fractures, type of fractures and its mechanism of injury.
2. To restore articular anatomy and congruity with stable internal fixation.
3. To assess the time of union of fractures treated by methods of open reduction and closed reduction .
4. To assess intraoperative and post operative complications.
5. To assess the range of motion of knee and note the knee score for each patient at every follow up.
6. To compare the functional outcome of patients with tibial plateau fractures treated with proximal locking plate by open reduction and closed reduction using Knee Scoring System by the Hospital for Special Surgery.

REVIEW OF LITERATURE

The treatment of tibial plateau fractures has changed dramatically over the past 50 years. Until the late part of 20th century, they were treated conservatively in the form of traction and cast bracing .

Apley [1] reported satisfactory results with traction and early mobilisation of knee.

Duwelius and Connolly[2,21] treated patients with closed reduction along with percutaneous pinning in some and early mobilisation in a cast brace and reported 89% of good to excellent results.

The favourable results observed in these studies provide an indirect evidence that the proximal tibial articular surface tolerates modest deformities and favorable outcomes can be obtained when reasonable limb alignment is achieved even without perfectly reducing the articular surface.

Koval et al.[3,17] used fluoroscopy to reduce 18 plateau fractures with screws. Out of 18 patients, 13 had excellent results.

Mills and Nork [11] achieved dual plating with minimal soft-tissue dissection and limiting subperiosteal dissection.

Ballmer, Hertel, and Nötzli reported the use of small fragment (3.5-mm screws) and AO/ASIF T-plates for fixation of 15 tibial plateau fractures.

Palmer I (1952) advocated surgery for any displacement or depression. Courvoisier E. (1965) suggested open reduction for any depression or displacement. Hohl M. (1967) and Rombold C. (1940) said if there is depression of more than 5 mm or lateral displacement of more than one cm, open reduction and internal fixation should be perfomed. Rasmussen (1973) performed open reduction for valgus or varus instability of 10 degree.

Moor T.M. and Harvey J.P. Jr. (1974)[41] used the tibial plateau view to measure the exact degree of depression before planning any surgery. Elstrom J., Pankovich AM, Sasson H. et. al. (1976) and J. J. Dias et. al [25] (1987) advised CT scan before planing any surgery to know the degree of depression, and type of fracture.

Schatzker and McBroom [22] (1979) concluded that open reduction with anatomical restoration of articular cartilage produces best results. In their study of 70 patients they obtained 78% acceptable results in the operated group as compared to 58% in the non-operated group.

Bowes in 1982 and Hohl [42] reviewed 52 tibial plateaus out of 110 fractures for more than one year. Non operative management was used in 72% of fractures. ORIF was used in 28%. Overall results were acceptable in 84% of patients. They used cast bracing in 31% of cases either as a primary treatment or after open reduction.

Blokker et al [43] in 1984 reviewed 60 tibial plateau fractures of which 75% patients had satisfactory results. According to them, the outcome of tibial plateau fractures was predicted by the adequacy of reduction.

Jensen S et al [44] (1990) reported that conservative treatment is valid alternative to surgery in cases where operation is not feasible.

Honkonen S. E and Jarvienen M.J [45] in 1992 analyzed 131 fractures of tibial condyles in 130 patients. In conservatively treated cases (55) subjective results were acceptable in 49% of cases, functional results in 60% and clinical result in 52.7% cases. In operative cases (76) they were 57.9%, 73.7% and 52.6% respectively. This study utilized single midline incision for open reduction.

Tscherene and Lobenhoffer [46] in 1993 studied 190 out of 255 cases and concluded that open reduction and internal fixation with the objective of obtaining accurate articular reconstruction, stable fragment fixation and allowing early motion , achieved good results even in extremely difficult fractures after open reduction.

Marsh J. L et al [47] in year 1995, treated 21 complex tibial plateau fractures by closed reduction and inter fragmentary screw fixation of the articular fragments and applied unilateral half pin external fixators. They

considered this external fixation as a satisfactory treatment for complex plateau fractures.

In 2002 Dennis P.Weigel and J. Lawrence Marsh [48], studied the long-term outcomes of treatment of high-energy tibial plateau fractures. They concluded that these patients treated with external fixation have satisfactory knee function during five years follow up.

Mahadeva et al , in a review of literature, concluded that management of Schatzker 5 and 6 type fractures is difficult. Hybrid external fixators have theoretical advantages in terms of the soft tissues but has no improved outcome over internal fixation.

Musahl V et al[3] reviewed the available literature concerning complex tibial plateau fractures and concluded that dual incision[4,11] bicolumn plating was indicated for fractures with posteromedial fragment, medial fracture dislocations and posterior metaphyseal fragments.

Carlos A. Bermudez et al[28,29] noted that configuration of many plates did not have provision to place screws to the region of the articular surface that needs support. In posterolateral or posteromedial fractures, the standard plates provide little support of posterior structures when placed from the front or side. Locking screws have the mechanical disadvantage[14,16,19] of cantilever loading when screws are placed front-to-back. Posterior plating can be difficult and

removal is also difficult if needed later. They described the use of horizontal rafting plates [9,10] to support the posterior fragments and the articular fragments through standard approaches. This method was used mainly to support the articular fragments.

In 2002, Gosling et al[18], presented their results in less invasive stabilization system in bicondylar fractures of tibial plateau and concluded that such injuries can be treated satisfactorily with lateral column locking plates.

Higgins et al[31] studied the comparative strength of lateral-only locking plate to medial and lateral non-locking plate in a cadaveric model of a bicondylar tibial plateau fracture. They showed that dual-plate fixation allows less subsidence compared to isolated locked lateral plates. They raised concerns about the widespread use of isolated lateral locked plate constructs in bicondylar tibial plateau fractures.

Gosling et al.[50] published the results of their study comparing the biomechanical stability afforded by lateral locking plate and bicolumn non locked plates. They concluded that both fixation techniques have a high resistance to vertical subsidence even with loads exceeding the average body weight.

Eric et al [49] (2006) published that in high energy tibial plateau fractures treatment is directed at safeguarding tissue vascularity. Fixation with

anatomically contoured plates using minimally invasive techniques can limit damage to the soft tissues, provide stable fixation and allow early fracture union. Complications like soft tissue disruption and infection are avoided by such biologically respectful principles.

Reduction of tibial plateau fracture for internal fixation can be done by two methods. Open reduction or direct reduction is a method in which the fracture site is surgically exposed after extensive soft tissue dissection and the fracture fragments are aligned following which internal fixation is done.

In closed reduction or indirect reduction method the fracture site is not exposed surgically. The key to reduction in this method is ligamentotaxis[51] by longitudinal traction. This can be achieved by using either fracture table or femoral distractor. The fracture fragments fall back into position during traction. Fracture reduction is verified under image intensifier and may be fixed provisionally using Kirschner wires. Internal fixation can be done by minimal invasive technique without disturbing the fracture site thereby minimizing soft tissue handling , reducing blood loss and surgical trauma area.

James et al [52] published that indirect reduction and submuscular plating by minimally invasive technique is superior in preserving blood supply to bone than open plating. A fracture damages nutrient vessels to the bone and

overlying tissues. Further surgical trauma in the form of periosteal stripping and muscle transection can retard bone healing and lead to complications. In high energy proximal tibia fractures where the is pre-existing precarious soft tissue condition, minimally invasive technique becomes more important to avoid complications [15,52] .

Barei et al[53] reported that "Single incision open reduction and double plate fixation of complex tibial plateau fractures has been associated with high wound complication rates. Minimally invasive methods have been recommended to decrease the wound complication rates as compared with open techniques. Additionally, laterally applied fixed-angle devices appear to minimize late varus deformity without the need for additional medial stabilization".

Biggi et al[54] reported 78% of good to excellent results in a cohort of 58 proximal tibia fractures and recommends internal fixation with locking plates using tissue sparring minimally invasive technique for satisfactory reduction, stable fixation and early rehabilitation.

APPLIED ANATOMY

The knee is the largest and most complex joint of the body. Being a synovial joint, it is of the modified hinge type: in addition to flexion and extension a small amount of rotation of leg is possible in flexed position. It is a compound joint consisting of two condylar joints between the femur and the tibia and a saddle joint between patella and femur.

The knee is composed of:

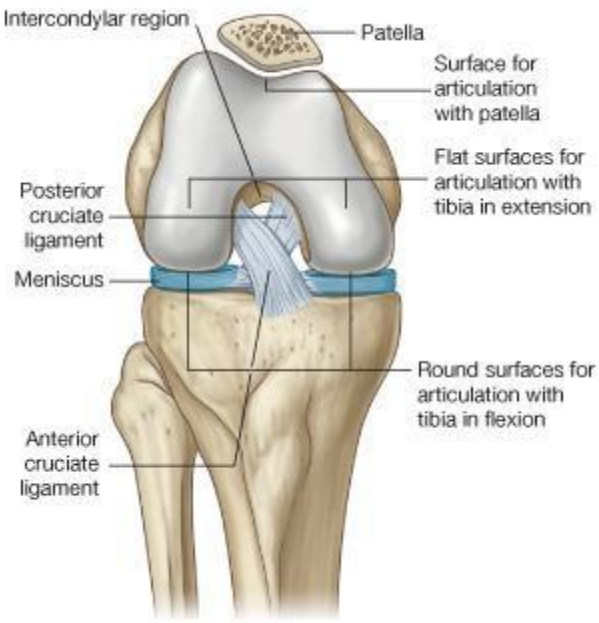
1. Osseous structures
2. Extra-articular structures
3. Intra-articular structures

OSSEOUS STRUCTURES

Femoral Condyles

The femoral condyles are two rounded prominences that are eccentrically curved, anteriorly the condyles are somewhat flattened, which creates a large surface area for contact and weight transmission.

The condyles project very little in front of the femoral shaft but more so behind. The articular surface of the medial condyle is longer than that of lateral condyle but the lateral condyle is wider.



Tibial Plateau

- It is the proximal articular surface of the tibia, expanded in transverse axis, transmits weight of the body from the lower end of the femur.

- It is composed of two parts- concave articular surfaces of oval shaped medial and circular shaped lateral tibial condyle.
- Medial plateau is larger, stronger and transmits more weight than the lateral plateau.

The articular surfaces on the plateau are not equal, the lateral being wider than the medial. In the sagittal plane, the lateral plateau appears convex and the medial plateau appears concave. This is to be correlated when viewing lateral X-Rays of knee joint since the lateral plateau is usually visible as it lies at a higher level than medial plateau. Thus neither plateau provides much assistance in stabilising the knee. According to Bohler, tibial plateau slopes posteroinferiorly 5-10 degrees from horizontal, with the plane of the articular surface forming an angle of 76 +/- 3.6 degrees with the tibial crest. It is important to bear this in mind when screws are passed from anterior to posterior in proximal tibial region. The peculiar nature of the articular surfaces results in different injury patterns. The medial tibial plateau is convex to the tibial side and axial load transmission leads to split fractures in medio lateral direction. The lateral tibial plateau is convex to the femoral side and axial load transmission leads to multifragmantary joint depression with joint broadening[1]. Additionally, the medial plateau has stronger trabecular bone owing to higher physiological stress in medial compartment of knee. Hence, medial tibial plateau fractures are less common compared to lateral plateau fractures. Medial

plateau fractures must alert the surgeon to an underlying severe violence and additional neurovascular injury must be surveyed for.

	
Anterior view of tibial plateau The lateral surface is convex and the medial surface is concave	**Medial view of tibial plateau** The concave medial surface is over ridden by the elevated convex surface in lateral radiographs

The non-articular area in the plateau surface contains anterior and posterior tibial spines. Anterior tibial spine lies medial and just posterior to the insertion of the ACL. The posterior cruciate ligament is attached in the posterior intercondylar area, extending onto the posterior surface of the metaphysis. It is imperative that the width of intercondylar eminence is reconstructed and to appropriately restore the anatomic width of the proximal end of the tibia.

The tibial tubercle is located over the anterolateral tibial crest about 2 cm below the anterior joint line and provides attachment for the patellar tendon.

The Iliotibial band inserts along the lateral tibial flare into a protruberence known as Gerdy's tubercle. Gerdy's tubercle forms an important landmark in anterolateral approach to proximal tibia. The fibular head is prominent along the posterolateral aspect of the tibial condyle and it provides attachment to the fibular collateral ligament and biceps tendon.

Patella

Patella, a triangular sesamoid bone in the extensor mechanism, is situated between the quadriceps tendon and patellar tendon. The proximal wider portion is the base of the patella and the distal pole is narrow called the apex.

EXTRA ARTICULAR STRUCTURES

The extra articular structures comprises of musculotendinous units and ligamentous units.

Musculotendinous units:

These are made up of:

i) Quadriceps femoris - Anteriorly

ii) Gastrocnemius - Posteriorly

Popliteus

iii) Semimembranosus

Semitentendinosus - Medially

Gracilis

Sartorius

iv) Bicep femoris - Laterally

Iliotibial band

LIGAMENTOUS STRUCTURES:

FIBROUS CAPSULE

The capsule is a sleeve of fibrous tissue extending from the patella and patellar tendon anteriorly. It is attached 0.5 to 1 cm beyond the articular margins.

Femoral attachment

- Anteriorly it is deficient and is replaced by quadriceps, patella and patellar tendon.
- Posteriorly it is attached to intercondylar ridge

- Laterally encloses the origin of poplitieus

Tibial attachment

- Anteriorly it descend to the tibial tuberosity along margins of the condyles.
- Posteriorly it is attached to intercondylar ridge.
- Posterolaterally it allows the passage of popliteus tendon.

The weak capsular ligament is strengthened

- Anteriorly by medial and lateral retinacula (extensions of v. medialis & v. lateralis). They are the principal stabilizers of the knee joint.
- Laterally by iliotibial tract

- Posteriorly by oblique polpliteal ligament
- Medially by tendons of sartorius and semimembranosus

The attachment of menisci is firm medially and less firm laterally. The capsule is well defined medially than laterally.

The tibial collateral ligament is long, rather narrow, well delineated structure lying superficial to the medial capsule inserting 7 to 10 cms below the joint line on the posterior one half of the medial surface of the tibial metaphysis deep to pes anserinus tendons. It provides the principle stability to valgus stress. The lateral or fibular collateral ligament attaches to the lateral femoral epicondyle proximally and to the fibular head distally. It is of prime importance in stabilizing the knee against varus stress with the knee in extension. As the knee goes into flexion, the lateral collateral ligament becomes less influential as a varus stabilizing structure.

INTRAARTICULAR STRUCTURES

These consist of the cruciate ligaments and the menisci. The two cruciate ligaments, anterior and posterior provide stability in the sagittal plane. They are extra synovial in location but intracapsular.

Anterior Cruciate Ligament:

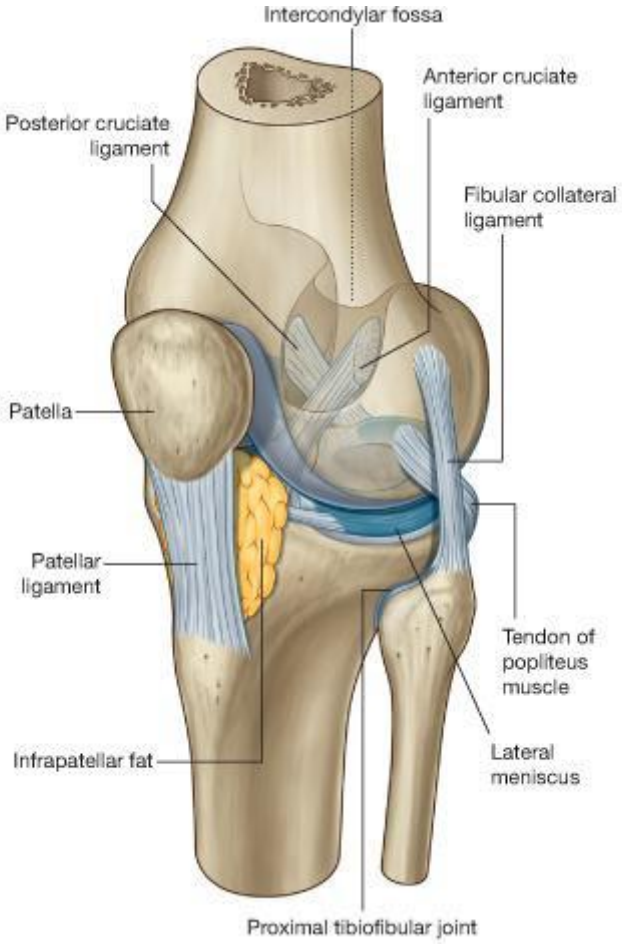
It is made up of bundles of fibres, which are taut in various degrees of knee flexion and extension. The average length of ACL is 3.8 cm and the average width is 1.1cm. The tibial attachment is in front of anterior tibial spine. It is the primary stabilizer against anterior displacement of tibia.

Posterior Cruciate Ligament

It is the primary stabilizer against posterior displacement of the tibia on the femur. It is almost vertical in its alignment in sagital plane. In the coronal plane it passes obliquely upwards and medially to its femoral attachment. The length of PCL is 3.8 cms and the width is slightly bigger than ACL about 1.3 cms and is more robust.

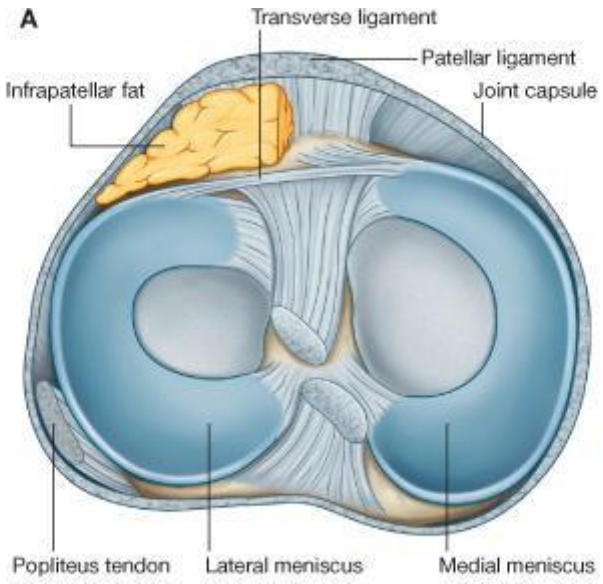
Menisci

These are wedge shaped semicircular fibrocartilaginous structures, two in number; medial and lateral present between femoral and tibial condyles. The important function of Menisci is in load sharing by protecting the articular cartilage from upto 60% of the load encountered by the knee. The meniscotibial ligaments attach these structures to the tibia. These structures should be identified and incised horizontally to gain visualization of the joint through a submeniscal exposure.



Knee joint after removal of joint capsule

Articular surface of tibia – seen from above



MECHANISM OF INJURY

Tibial plateau fractures occur more commonly in adults in 3rd to 5th decade. Men at younger age sustain fracture due to high energy injuries and women in advanced age due to osteopenia.

Road traffic accidents, fall from height and bumper injuries occur in younger age and even simple falls leads to injury in elderly.

The fracture pattern depends on magnitude, type and direction of force.

Axial loading result in worse injuries when compared with angular forces.

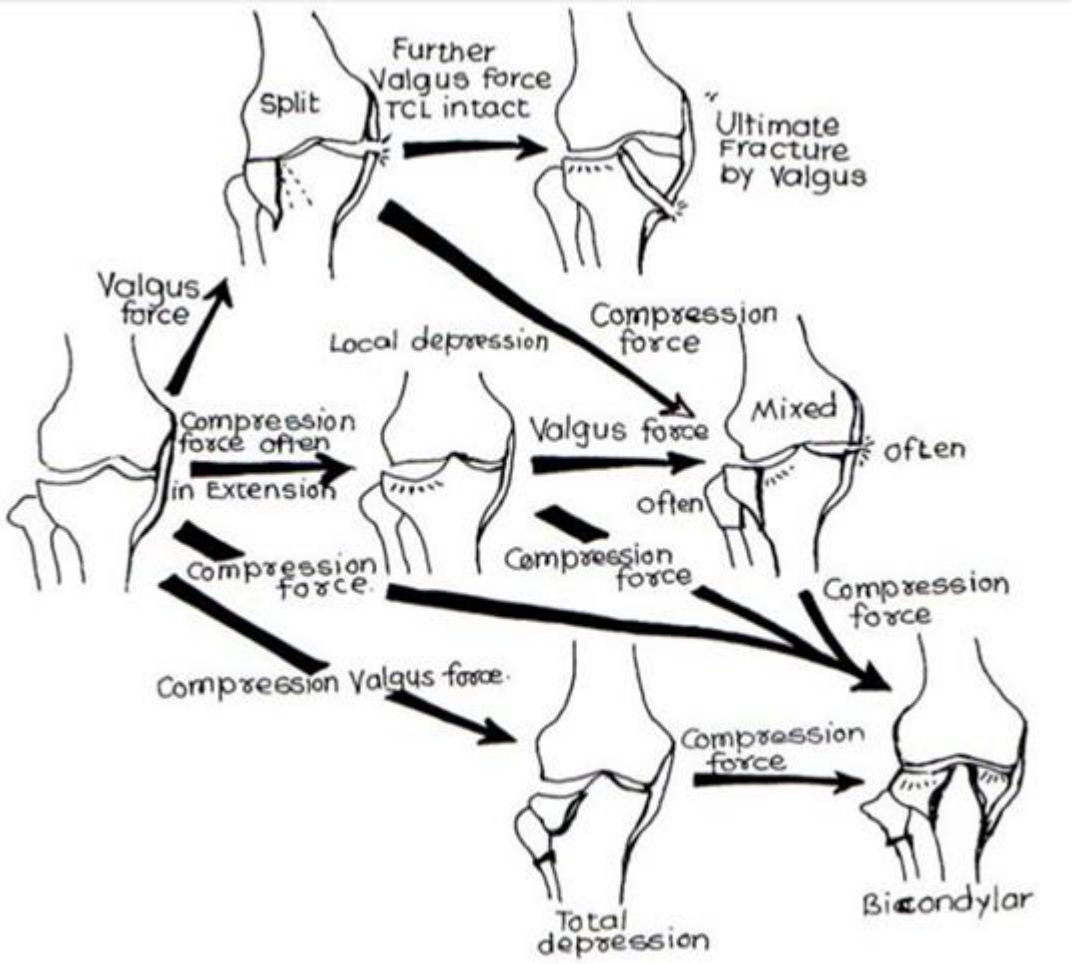
Valgus forces are more common because of normal 5 to 7 degrees valgus alignment of knee and the direct hit is usually on the lateral side.

Combination of valgus and axial loading force results in lateral plateau fractures.

Posteromedial shearing fracture is common on the medial side due to knee flexion, varus and internal rotation.

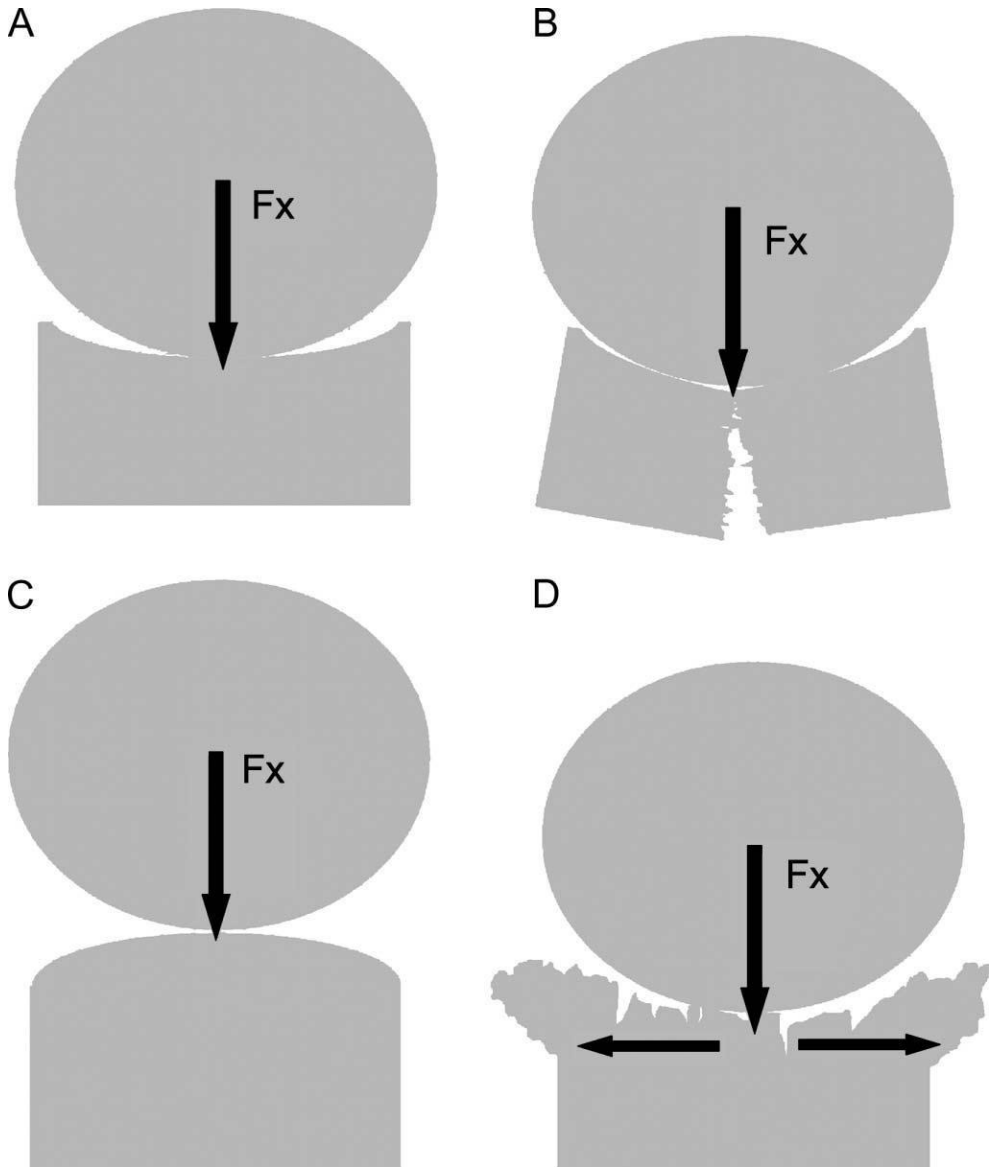
Tibial plateau fractures occur with the leg in weight bearing position. So the axial load is definitely one of the components of forces causing fracture. More the axial load, severe is the fracture.

Metaphyseal fracture occurs due to direct trauma and bumper injuries with the combination of axial load and bending forces.



Relationship of force to tibial condyle fractures

Fracture of the lateral tibial plateau is usually associated with severe comminution and joint widening, and medial plateau fracture has characteristic posteromedial shear fracture. It is explained on the basis of anatomy of the joint[1]. The medial plateau is convex to the tibial side and the femoral condyle glides around a constant center of flexion. Axial loading from the femur to the tibial condyle leads to a blasting of the tibial tray. The medial tibial plateau slopes posteriorly and the resulting force vector acts posteriorly, leading to a posterior split fragment. Similarly the lateral plateau is convex to the side of femur and there is no constant center of rotation. During flexion, the rotation axis moves posteriorly on the tibia. Axial loading produces an impression similar to a push-in of an eggshell. Thus, more the flexion of the knee, the more posterior is the depression of the joint.



Fracture mechanics: A: Medial condyle of knee is convex towards tibia, hence axial loads produce coronal plane split fragments (B). C: Lateral condyle is convex towards femur, and axial loads produce comminution and joint widening (D)

CLASSIFICATION

Commonly used classification systems for tibial plateau fractures

1. Schatzker classification
2. Hohl and Moore classification
3. AO/OTA classification

1. **Schatzker classification**

Most widely used system and familiar to most. There are six types in this system. All six types are treated differently and hence this system proves quite useful.

Type I—pure split: Wedge-shaped uncomminuted fragment. This fracture is common in younger patients without osteoporotic bone.

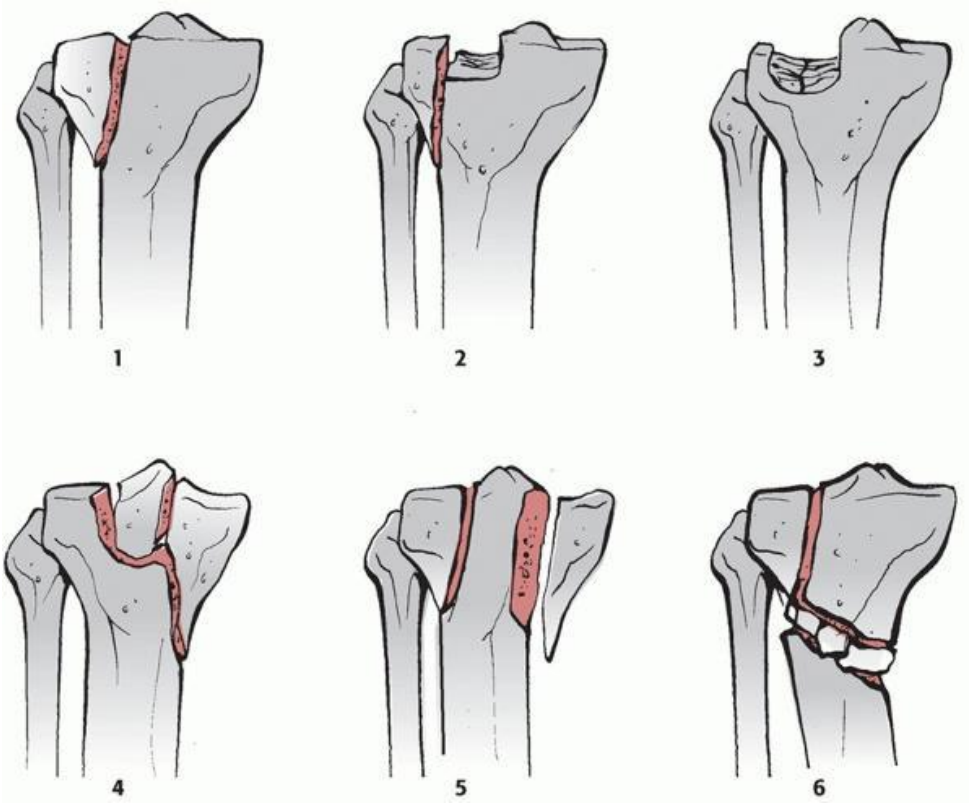
Type II—split with depression : A lateral wedge with articular surface depression .

Type III—pure central depression: The articular surface is driven into the plateau. The lateral cortex is intact. These tend to occur in osteoporotic bone.

Type IV—fractures of medial condyle: These may be split off as a single wedge or may be comminuted and depressed. These fractures tend to angulate into varus.

Type V—bicondylar fractures: Both tibial plateaus are split off. The distinguishing feature is that the metaphysis and diaphysis retain continuity.

Type VI—bicondylar tibial plateau fracture with dissociation of metaphysis and diaphysis.



2. Hohl and Moore classification

Hohl and Moore described a classification system for fracture dislocations injuries and neurovascular injuries.

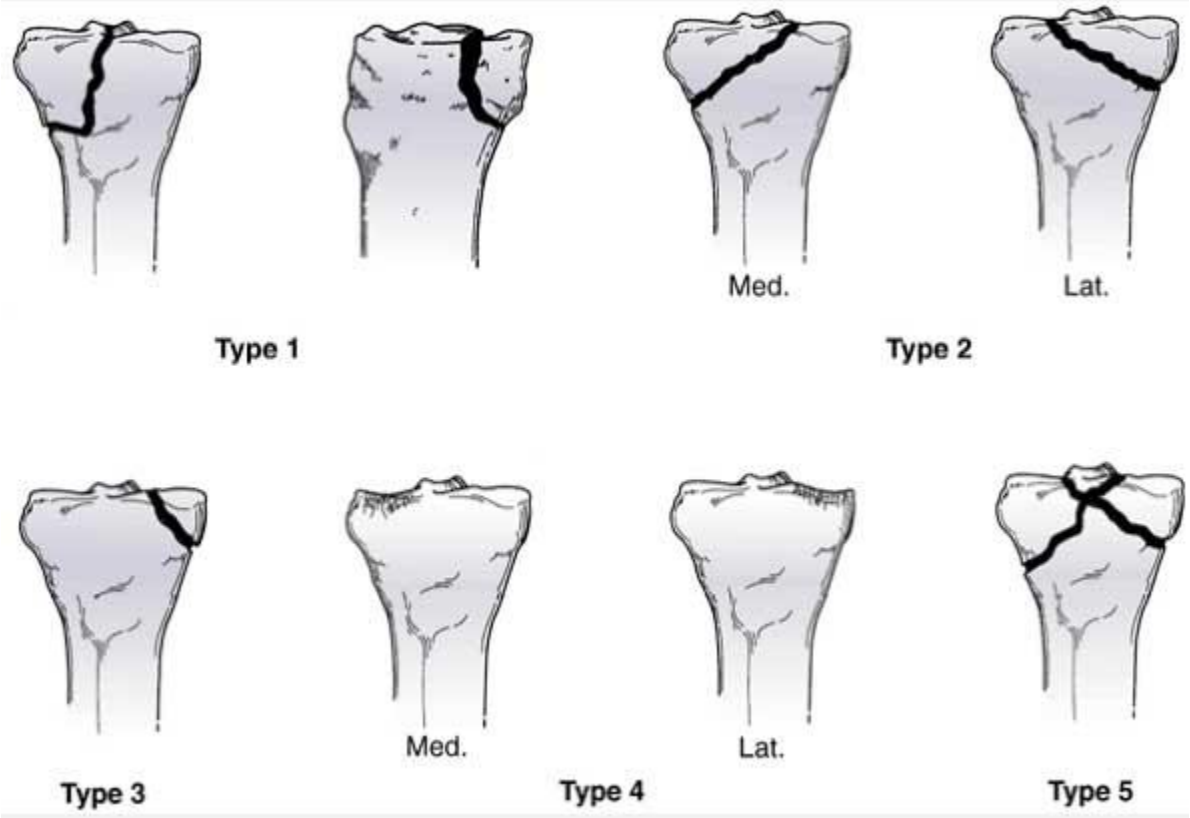
Type I - Coronal split fracture: Fracture of the medial condyle and is seen in lateral view. The fracture may extend to the lateral side.

Type II - Entire condyle fracture: Fracture – dislocation of one of the condyles. This is distinguished from the Schatzker type I and IV by fracture line extending into the opposite compartment under the intercondylar eminence.

Type III - Rim avulsion fracture: Severe valgus/varus stresses cause the capsular and ligamentous attachments to avulse from the rim of the respective plateaus. This is seen almost exclusively in lateral plateau.

Type IV - Rim compression fracture: Opposite side collateral ligament ruptures and causes opposite femoral condyle to compress the rim of the plateau.

Type V four part fracture: In this injury, there is bicondylar fracture, avulsion of both collateral ligaments and separation of intercondylar eminence. These are highly unstable. Neurovascular injuries are seen in almost 50% cases.


Med.
Lat.
Type 1
Type 2
Med.
Lat.
Type 3
Type 4
Type 5

3. AO/OTA Classification

In AO/OTA system, proximal tibia is denoted as 41 and these fractures are divided into extraarticular, partly articular and complete articular fractures.

Type A: Extraarticular, hence tibial plateau is not involved

Type B: Partial articular

B1 – Simple articular split

B2 – Split depression

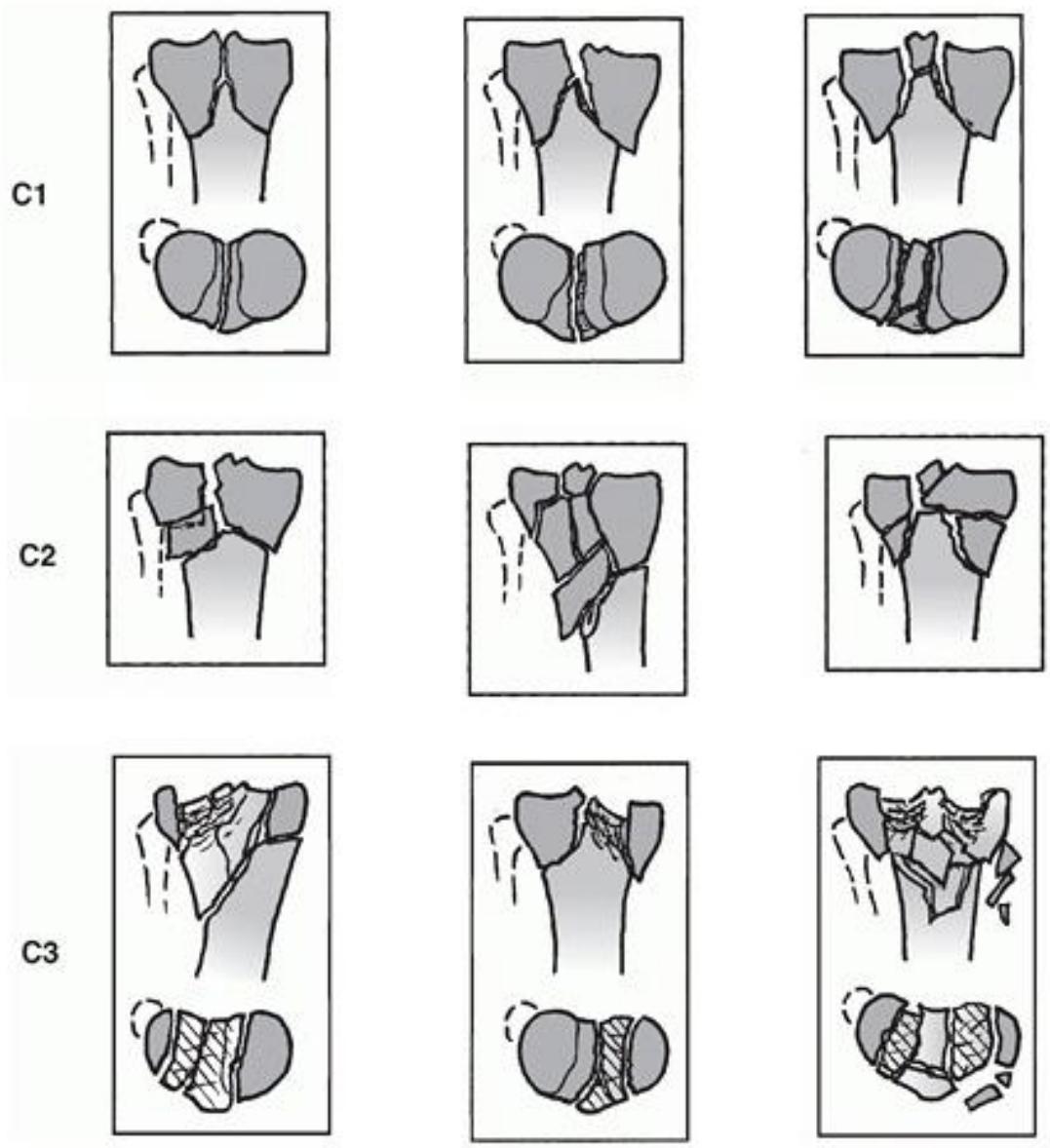
B3 – Comminuted split depression

Type C: Complete Articular

C1 – Non-comminuted total articular fractures

C2 – Metaphyseal comminution with simple articular fracture lines

C3 – Total comminuted articular fractures including the articular surface


C1
C2
C3

PRINCIPLES OF TREATMENT

NON OPERATIVE TREATMENT

Non operative management is used wisely in selected cases of tibial plateau fractures with satisfactory results.

Conservative Management involves treatment with splint, cast and traction with early knee motion.

Indications:

- Fractures that can be expected to heal without a significant deformity

- Elderly patients who have poor surgical risk

- Co existent medical morbidities with poor surgical risk

Lansinger obtained good functional outcomes in fractures of lateral plateau with mild to moderate articular depression (upto 10 mm)[27] by non operative management . But associated split and displaced fragments or larger articular depression usually heals with a valgus alignment and hence have a great risk of osteoarthritis due to uneven joint loading.

Isolated medial condyle fractures, even with minimal displacement, have greater chances of healing in varus malalignment because of the peculiarity of

the fracture pattern, tending to have more obliquity in the coronal plane. Hence anatomical reduction is recommended for all medial condyle fractures [1,3,33].

Given this background, it is usually unacceptable to treat bicondylar fractures in young, active adults non operatively as the functional results can be expected to be substandard.

OPERATIVE TREATMENT

Methods of operative management includes –

- Cannulated Screw fixation,
- AO ASIF Buttress plate (T/L)
- Proximal tibial locking plate with screws
- Arthroscopically assisted screw fixation
- Hybrid external fixator

Indications

- Bicondylar fractures
- Associated metaphysiodiaphyseal dissociations
- Split lateral condyle fractures
- Articular depression

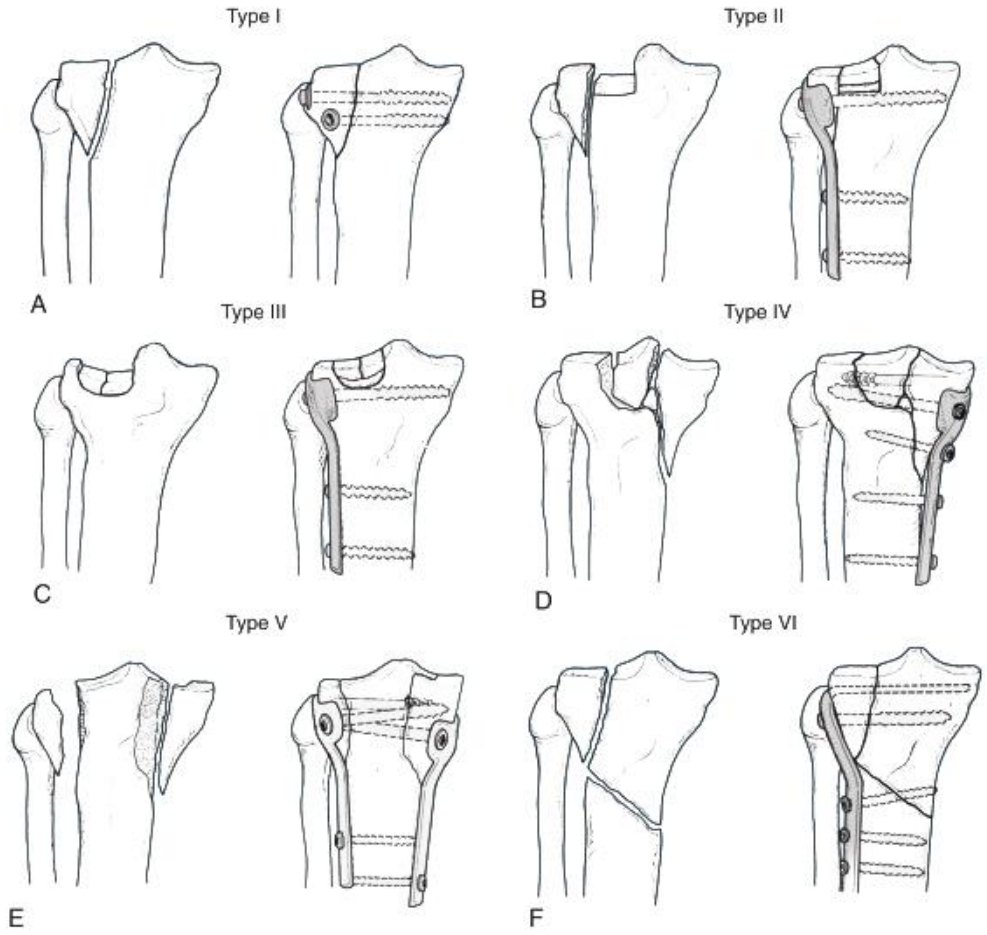
- Displaced fractures of medial condyle

- Valgus or varus instability > 10 degrees in 0 to 90 degrees knee arc of motion

- Open fractures

- Associated arterial injury or compartment syndrome

The advantages of surgical treatment are anatomical reduction, rigid fixation, anatomical and mechanical limb alignment and early joint mobilization. The choice is between internal and external fixation, with proponents for each.



Plates and screws

Plates and screws are commonly used implants in management of tibial plateau fractures.

Simplest one is 6.5mm partially threaded lag screws for simple fractures either used alone or along with other implants

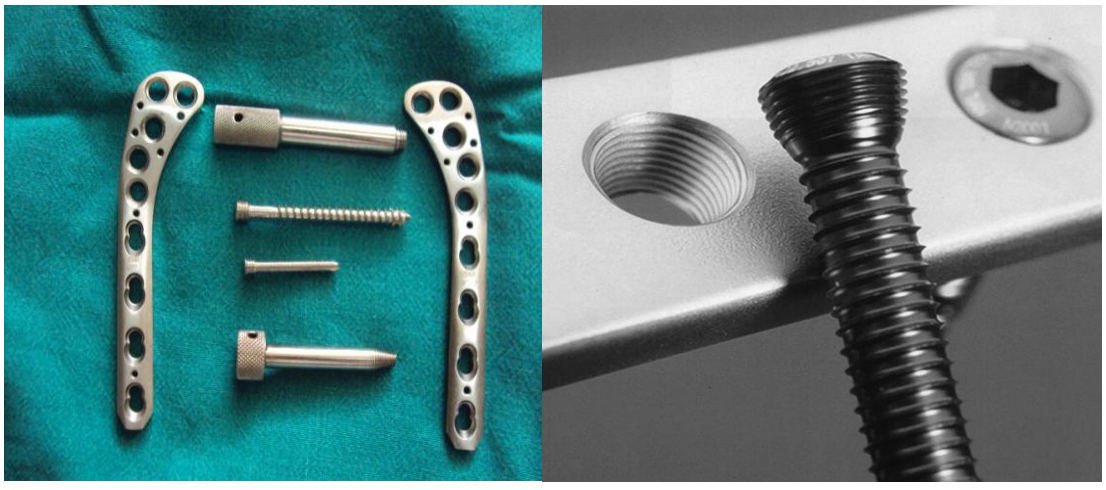
Plates are anatomically precontoured and periarticular. They are usually applied on anterolateral surface of tibia, used as a buttress to support fractured lateral cortex.

Plates available are buttress (L/T shaped) and locking compression. Various precontoured plates are available which are very easy to apply.

The most common position of plate in tibial plateau is the anterolateral region of proximal tibia. This plate acts as a buttress to support the weak lateral cortex of tibia in split and depression types of tibial plateau fractures.

In conventional buttress plating the screws are not locked. This increases the chances of screw movement and failure at screw head-plate interface. This can cause screw breakage, screw movement or subsidence of fragment. The locking plates and screws act as a single unit and hence this complication is avoided.

Locking plates in lateral column have been extensively used in bicondylar fractures recently. These are sturdier implants with stronger screws that provide resistance to the deforming forces at play in high energy bicondylar fractures.



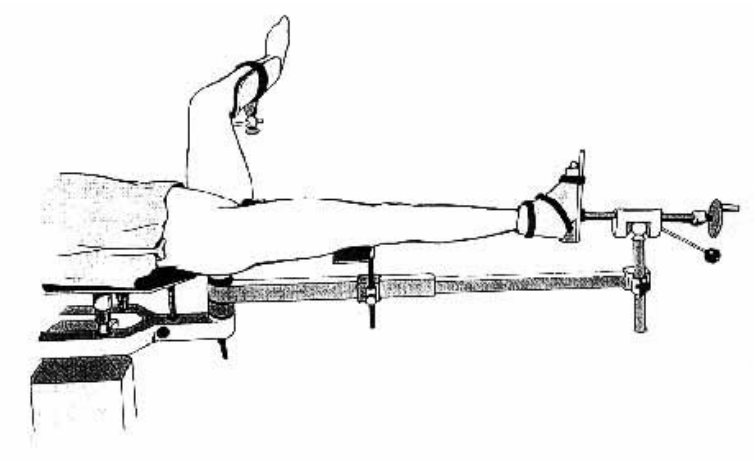
Locking Compression Plate and Screws

Methods of reduction

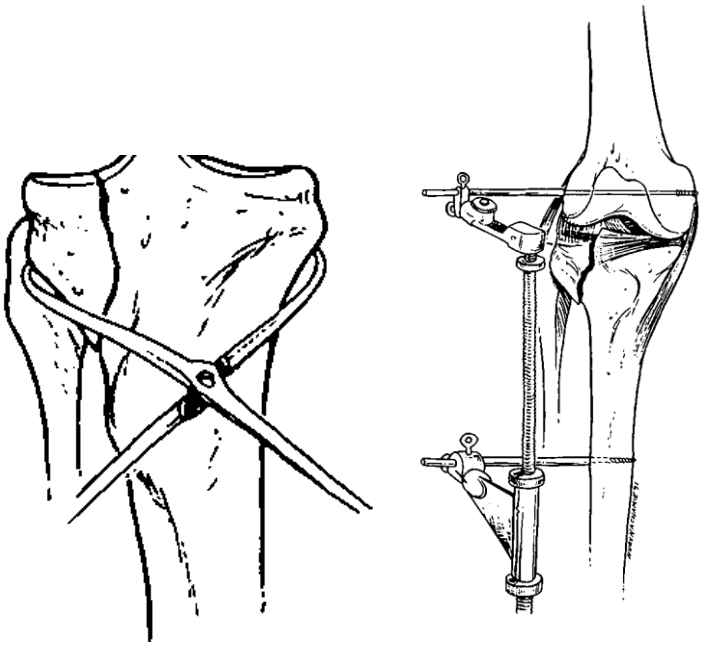
Being a periarticular fracture, that too in a major weight bearing joint like knee fracture reduction should be accurate to restore the limb biomechanics. It can be achieved by two methods like open or direct method and closed or indirect method.

Open reduction or direct reduction is a method in which the fracture site is surgically exposed, fragments are aligned under direct vision following which internal fixation is done

In closed reduction or indirect reduction method the fracture site is not exposed surgically. On the contrary it is reduced indirectly using the ligamentotaxis principle. Here the key to reduction is longitudinal traction using either fracture table or femoral distractor. During distraction the fracture fragments fall back into position which is possible only if the patient presents early . Reduction can be be secured using reduction clamps and verified using image intensifier. Provisional fixation can be done using Kirschner wires. Internal fixation can be proceeded by minimal invasive technique without involving the fracture site.



Indirect reduction using Fracture table



Indirect reduction using Femoral Distractor

Open/Direct reduction technique	**Closed/Indirect reduction technique**
Fracture site is surgically exposed	Fracture site is not exposed
Reduction under direct vision	Reduction by ligamentotaxis
	Image intensifier verification for fracture reduction
	Decreased surgical trauma area

***External fixators**:*

Temporary external fixation is applied spanning the knee joint and restores limb alignment and maintains limb length, thus aiding soft tissue recovery before definitive internal fixation. High energy bicondylar fractures may be treated definitively using external fixators when there is severe soft tissue injury or as per the preference of the individual surgeon. The results of definitive external fixation may prove as good as internal fixation in high energy injuries if the frame is applied in a competent manner with adequate stability [37]. Hybrid fixators and joint sparing fixators are useful in this regard.

COMPLICATIONS

Articular fractures of the proximal tibia on treatment may be followed by a number of complications that result from the nature of fracture, the treatment employed and also the patient.

Complications can be divided into two types namely

1. Early
2. Late

EARLY COMPLICATIONS

a) Thrombophlebitis and Embolism

Due to immobilization of a leg or due to knee injury thrombophlebitis develops in the calf or thigh. In the presence of thrombophlebitis, treatment options may be quite limited and results significantly affected.

Pulmonary embolism is seen in a small proportion of patients. It may sometimes occur silently but usually causes pleuritic chest pain, bloody sputum and breathlessness.

The diagnosis is made reliably by the available tests.

b) Fat Embolism

Fat embolism is one of the earliest complications in tibial plateau fracture treatment. Diagnosis is usually established by the presence of petechial hemorrhages, change in fatty enzymes and decreased PO2 in arterial blood. Fat embolism is treated with the use of corticosteroids and oxygen to improve respiratory exchange and supportive methods.

c) Compartment Syndrome

It is commonly manifested clinically by pain, which increases with duration and is located most frequently over the proximal portion of the anterior compartment. It is tested by measuring pressures in all the compartments of leg. Early and complete release of fascia comprising the affected compartments is the ideal treatment. In order to avoid compartment syndrome after open reduction of a lateral plateau fracture, the fascia should not be tightly closed.

d) Arterial Injury

Injury to the popliteal artery may occur due to bicondylar fractures with sharp spicules of bone or plateau fractures especially those with a subcondylar component. Surgical repair of the injured artery is carried out as an emergency, reserving fixation of the fracture until arterial circulation has been reestablished. Internal fixation may be accomplished later, but closed management technique may also be used effectively.

e) Paralysis of Peroneal nerve

The anatomical course of the common peroneal nerve around the neck of the fibula makes it very much vulnerable to injury due to direct trauma against the lateral aspect of the knee or by similar injuries that may also damage lateral ligaments of knee. Damage to Peroneal nerve usually occurs during fracture but can also result due to direct pressure on the nerve against plaster cast or traction sling, or from retraction in surgery. Late neurolysis of the peroneal nerve is rarely required and the prognosis for recovery is favourable. Mostly nerve injuries recover with normal function within a period of 6 months.

f) Loss of Fracture Reduction

There are strong muscle forces acting across the knee joint. Fractures involving the articular surface of the proximal tibia are affected by these strong muscle forces and hence tend to displace owing to the pressure of the femoral condyle over the tibial plateau.

g) Wound Infection

Wound infection is the most common complication of open reduction of tibial plateau fracture. Problems related to wound healing are seen most commonly after operative treatment of bicondylar fractures, probably because of the ill timed surgical incision through contused skin with extensive exposure, retraction, metallic implants and operating time.[23]

Prophylactic antibiotics and newer surgical techniques have fostered the current favourable attitude toward operative fracture management. Careful attentions to skin condition, intra operative antibiotics, surgical approaches requiring little retraction, and stable fixation have minimized the risk of wound infection. The duration of antibiotic therapy depends on the clinical appearance of the wound and laboratory assessment of infection and bacteriological reports. Soft tissue closure is usually recommended within five to seven days. If tension free closure cannot be obtained, medial or lateral gastrocnemius flap with subsequent split skin grafting later on can be done.

h) Avascular Necrosis

Exposure of fractured tibial plateau by their release from soft tissue attachments leads to avascular necrosis. Necrosis of elevated fragments in local compression or split compression fractures is rarely seen. Bony fragments need to be exposed in order to accomplish accurate reduction and rigid fixation. Minimum soft tissue dissection will reduce the risk of avascular necrosis in bony fragments. Avascular necrosis can be prevented by percutaneous methods of fixation in the bony fragments.

i) Nonunion

Pseudoarthrosis of a tibial plateau fracture due to non union is quite uncommon. Cancellous bone in the tibial plateau region is highly vascular,

which favors rapid bony union. Moreover, non union occurs in about only one in 200 plateau fratures[24]

Non-union is commonly seen with Schatzker type VI. Treatment of non-union must be aggressive. Bone grafting is usually successful when combined with stable internal fixation. In case of infected non-union antibiotic impregnated beads, rotational free flaps and external fixation are the mainstay of treatment.

j) Implant Complications

Internal fixation devices may break up, slip and cause irritation, when skeletal traction or external fixation pins are used. Infection of pin tracts may lead to osteomyelitis rarely. Hardware breakage and displacement occurs more often with wires or bolts rather than cancellous screws or buttress plates.

k) Causalgia

Causalgia is a rare complication following incomplete injury to the infrapatellar branch of the saphenous nerve, such as by stretching during surgery or by local bruising from the initial injury. The treatment is comprised of local anaesthetic injection of the involved nerve, exploration of the nerve with neurolysis or paravertebral sympathetic blocks.

LONG TERM COMPLICATIONS

(a) LIMITATION OF KNEE MOVEMENTS

It is a well-known fact that the process of healing of articular injuries utilizes scar tissue that tends to envelop the articular structures. If the knee is kept immobilized during this period of intense scar formation, dense adhesions arise from the fracture to the synovium, encompassing the menisci and fat pad. Late arthrotomy and arthroscopy confirms the presence of multiple intra articular adhesions.

To ensure functional range of knee movement after a plateau fracture, the best method is treatment that allows early knee motion. If stable fixation has been obtained, early knee motion should be definitely encouraged. In cases of adhesions formation, Arthroscopic lysis with gentle manipulation of the knee is done.

(b) LACK OF KNEE EXTENSION

In case of lack of knee extension, the gait is altered and walking becomes more difficult. Even few degrees of flexion contracture can cause some degree of gait impairment. Flexion contractures occur due to prolonged immobilisation in flexion, and associated subcondylar fracture that has got united with anterior angulation, and failure to reduce the articular fragments and maintain their anatomical position.

(c) ANGULAR DEFORMITY

As lateral plateau fractures occur more commonly, valgus deformity predominates. The main reasons for angular deformity are healing of a plateau below its normal level, and Traumatic arthritis

Due to loss of articular cartilage and articular bony surface erosions, angular deformity can be prevented by accurate reduction, and its maintenance. In case of established deformity, a subcondylar osteotomy is mainly used to correct the alignment. Unicondylar or total knee replacement is a better choice than osteotomy in case of patients with poor health and patients more than 70 years of age.

(d) INSTABILITY

The reasons for late instability after plateau fractures are failure to reduce and maintain reduction of plateau surface, ligament laxity secondarily to an unrepaired collateral or cruciate ligament injury, and traumatic arthritis with loss of articular cartilage and erosion of the articular cartilage. This instability often leads to the development of late knee pain. If knee instability can be recognized early in the treatment and restored, it will help to minimize pain later on and reduce the degree of traumatic arthritis.

(e) TRAUMATIC ARTHRITIS

There is no universal agreement as to what constitutes traumatic arthritis in the knee and the reported incidence following plateau fracture varies greatly from about 10-78%. Squaring of the femoral and tibial condyles is the earliest change seen on X-ray. Other changes occur, including spurring on the tibial spines and joint margins, sclerosis of the subchondral bone, joint space narrowing and finally cyst formation in the articular subcortex.

Posttraumatic osteoarthrosis leads to articular incongruity and joint instability. Varus malalignment of the tibial plateau is less tolerated than valgus malalignment. If arthritis is limited to medial or lateral compartment with altered mechanical axis corrective osteotomy indicated. If bicompartmental or tricompartmental, an arthrodesis or total knee replacement is necessary.

MATERIALS AND METHODS

This is a retrospective and prospective study conducted in Rajiv Gandhi Government General Hospital, Chennai, from July 2014 to September 2015.

Twenty patients who satisfied the following criteria were included in the study.

Inclusion Criteria:

Adults with closed Schatzker type V and VI Tibial plateau fractures.

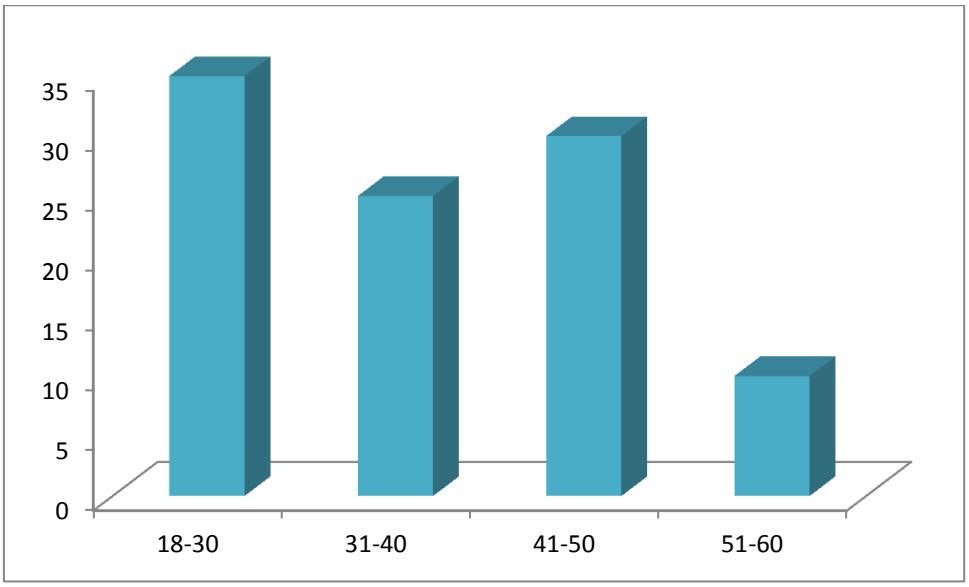
Exclusion criteria:

- Type I to Type IV Schatzker Tibial plateau fractures
- Patients with associated ipsilateral lower limb fractures
- Compound fractures
- Compartment Syndrome
- Vascular injury
- Patients presenting late - more than 21 days after fracture.

AGE DISTRIBUTION

The age of patients in our study ranges from 19 to 55 years.

Age group	No. of patients	Percentage %
18-30	7	35
31-40	5	25
41-50	6	30
51-60	2	10

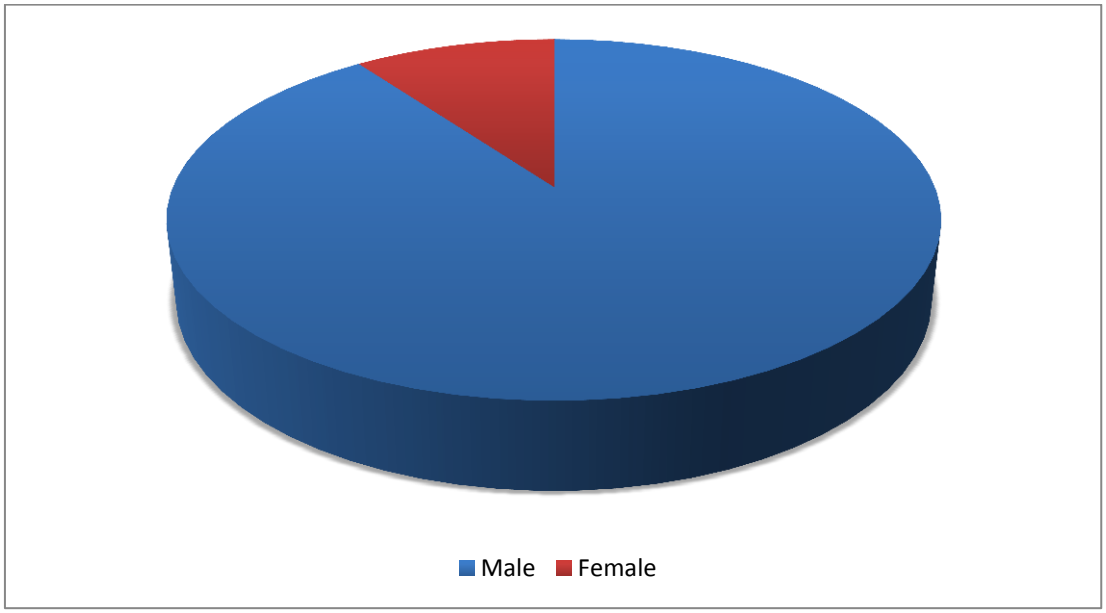


SEX DISTRIBUTION

In our study no. of males were more than females.

Male: 18

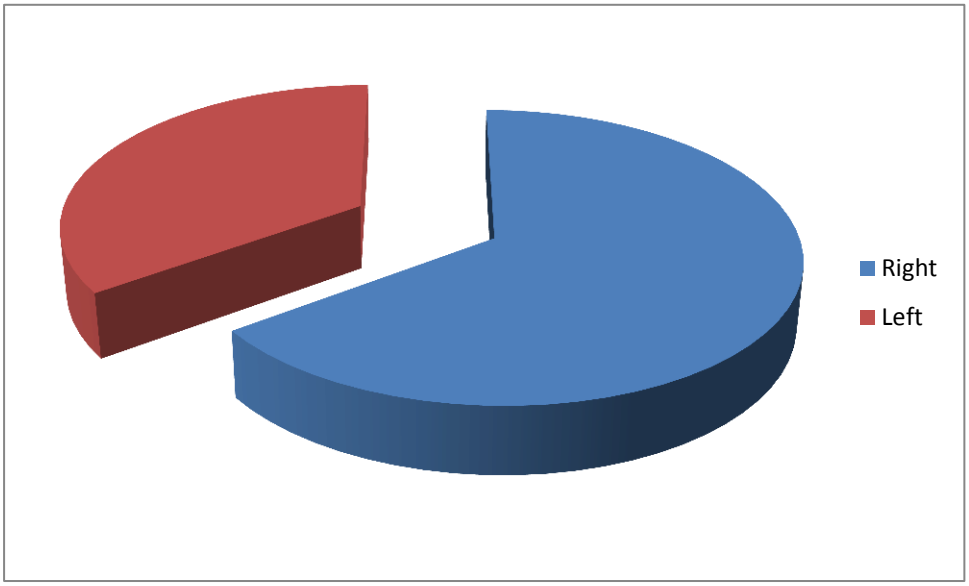
Female: 2



SIDE DISTRIBUTION

Among 20 patients, injury was on right side for 13 patients and left side for 7 patients.

Side affected	No.of patients	Percentage
Right	13	65
Left	7	35



DIAGNOSIS

HISTORY

A detailed history to elicit the mechanism and severity of injury was obtained.

Patient's personal, medical and occupational history was obtained to know the problems and complications that may arise during or after surgery; also to know the functional demand of the patient.

History to look for associated injuries in the head, chest and abdomen was also asked for.

PHYSICAL EXAMINATION

Patients with tibial plateau fractures usually present with painful swollen knee and are unable to bear weight.

High energy injuries are associated with soft tissue compromise and neurovascular compromise.

Soft tissue compromise was evidenced by superficial abrasions, deep contusions, discoloration of skin, blisters and open wound. In these cases surgery was postponed till soft tissue healing takes place.

Compartment syndrome was assessed by frequent examinations of the leg. Disproportionate pain, pain on passive stretch of toes, paresthesia, pallor, absent or diminished pulses point towards onset of compartment syndrome. In doubtful cases, ankle brachial index was obtained. Lachman test was performed to assess ligamentous injury.

IMAGING

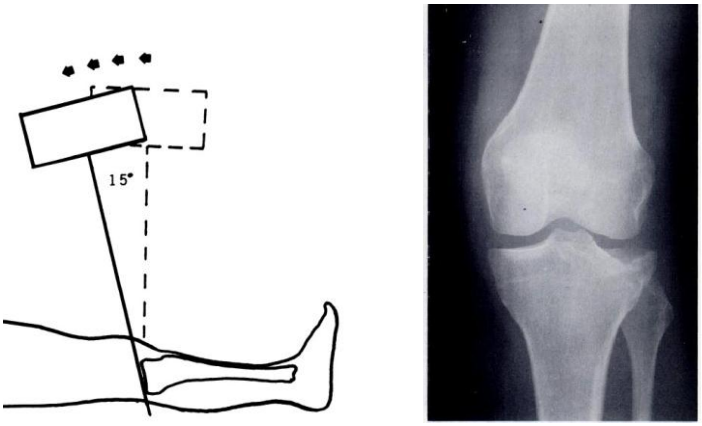
Radiography

Anteroposterior and lateral X-Rays of knee were taken to know the fracture pattern.

In the AP view, 10° caudal tilt view clearly shows the articular surface depression and split than the standard AP view.

Oblique views detect minor degrees of joint impaction and fracture line more clearly.

Traction views are useful in severely comminuted and displaced fractures.



Tibial plateau view: Technique and x ray picture

Computed Tomography (CT)

CT scanning with axial, coronal and sagittal planes is the imaging study of choice to assess the fracture pattern and determine the location of articular comminution and depression. Three dimensional reconstructive images also guide the management[35,36].

CT Scans help to classify the fracture, guide pre-operative planning and decide the choice of treatment.

CT images

MANAGEMENT PROTOCOL

PREOPERATIVE MANAGEMENT

On admission patients were started on an i.v. line and fluids infused. Analgesics were given i.m. The injured limb was temporarily immobilized in Thomas splint and X-ray taken. CT scan was taken to assess three-dimensional fracture geometry.

Ice fomentation and limb elevation were done. After the swelling above knee slab or calcaneal pin traction. Skin over fracture was closely watched.

SURGICAL PROCEDURE

Patients were thoroughly investigated and anaesthetic assessment obtained. Surgery was done under spinal anaesthesia. The affected knee was prepared, painted and drapped.

For OPEN reduction:

Patient was placed in supine position, with folded pillow under knee to allow knee flexion.

ANTEROLATERAL APPROACH

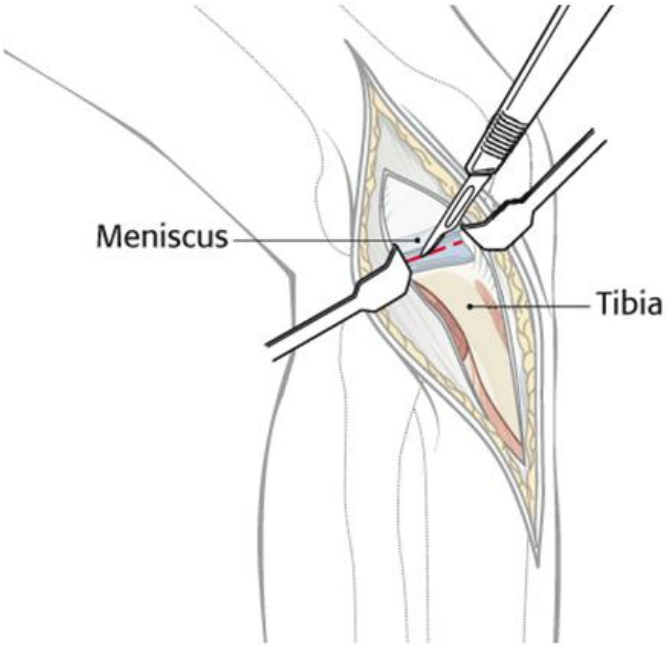
Lateral plating was done using this approach.

This is the most common approach used to surgically reduce and fix tibial plateau fractures. The incision is based on Gerdy's tubercle and extended

distally over the anterior compartment. An L-shaped incision over the origin of the anterior compartment muscles provides access to the anterolateral surface of the tibia. Care should be taken along the posterolateral border of the tibia to protect the anterior tibial artery as it passes through the interosseous membrane from posterior to anterior.

With the knee flexed in a varus and internally rotated position, the intra-articular damage was evaluated through a submeniscal arthrotomy.

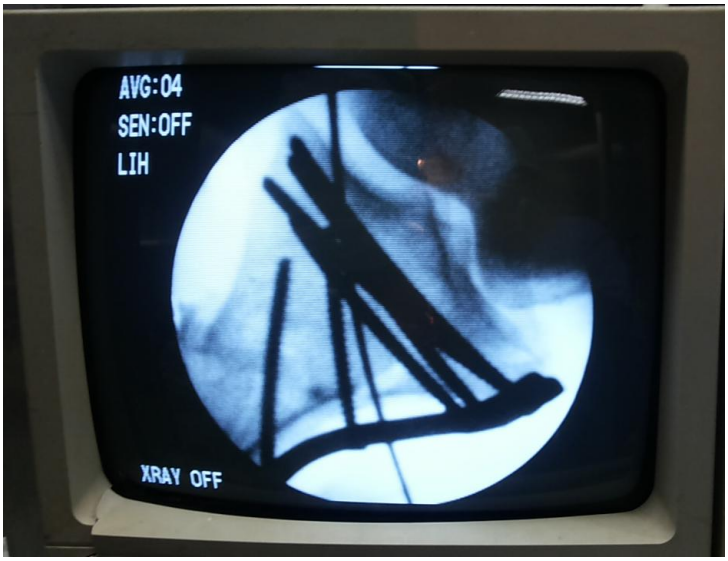
The fracture was mobilized with a chisel and reduced directly under vision and a compression clamp was applied across the transverse diameter of the tibia. Finally, a lateral locking compression plate was used to stabilize the lateral compartment. This allows the mediolateral direction of the screws.



Anterolateral approach

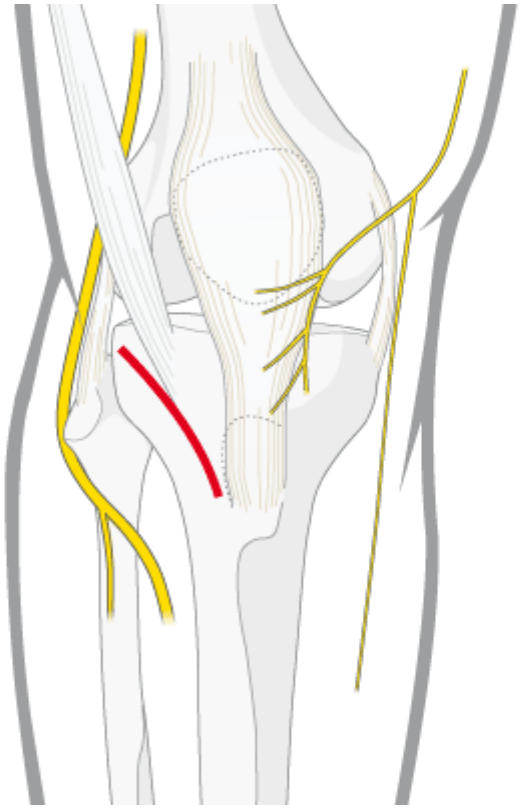
INTRAOPERATIVE IMAGES

INTRA OPERATIVE FLUOROSCOPY

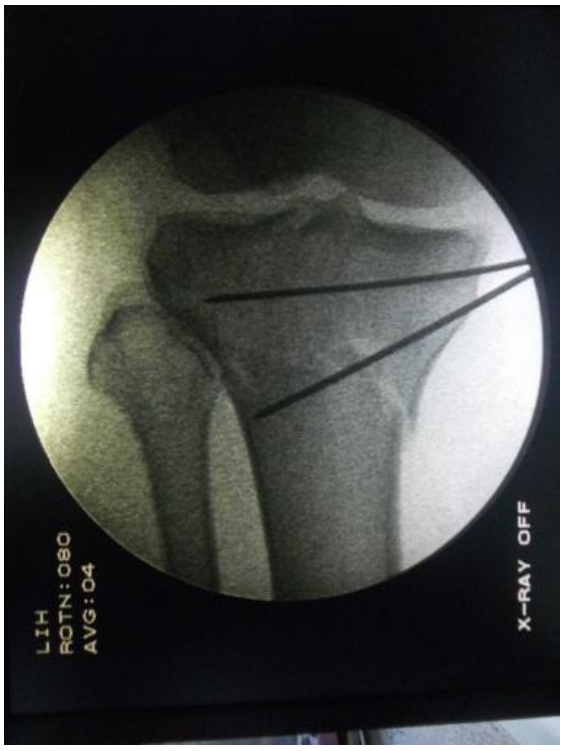


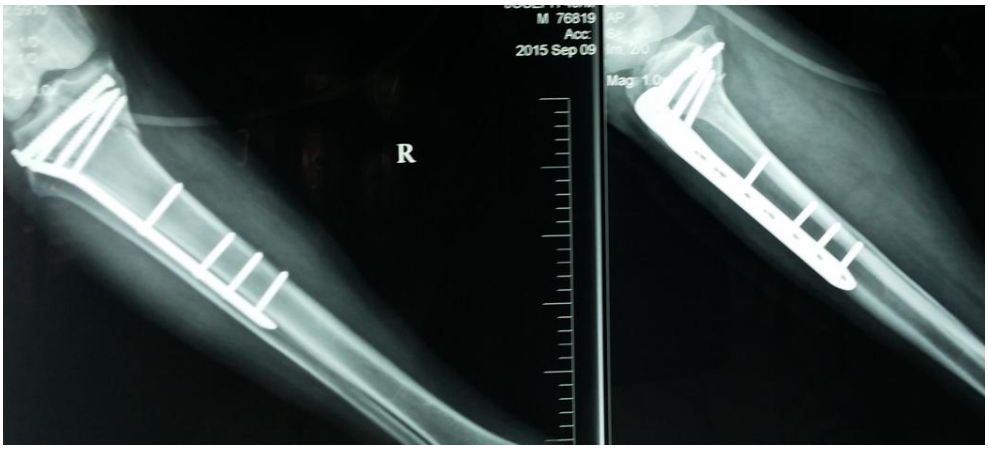
For CLOSED reduction:

The patient was positioned supine on fracture table with the affected limb attached to the traction unit. Fracture was reduced under image intensifier guidance by longitudinal traction applied using the traction unit. Reduction was secured using compression clamps and Kirschner wires. The same approach was used but fracture site was not exposed. The lateral locking compression plate was slid into submuscular plane and screws were applied.



INTRAOPERATIVE IMAGES

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POST OP PROTOCOL

- Quadriceps exercise started as early as patient tolerates pain.
- Non weight bearing until signs of union are visible, usually around 12 weeks postoperatively.
- Range of motion exercises are started 10 to 14 days postoperatively to allow wound healing.
- Patient was discharged with the instruction of knee mobilisation exercise, quadriceps exercise and non-weight bearing.
- Range of motion was noted using goniometer.

FOLLOW UP

- Patients were followed up at monthly interval.
- Functional outcome was analyzed using Knee Scoring System devised by the hospital for special surgery.
- X ray of tibia including both the knee and ankle joints were taken in both anteroposterior and lateral views. Joint reduction was assessed for any articular step off or misalignment.
- Misalignment in the form of varus or valgus was assessed with anteroposterior tibia Xrays that included both knee and ankle joints. The varus or valgus angle was measured.
- Range of knee motion was measured using goniometer.

- Data obtained were filled in the proforma.
- Partial weight bearing started after 12 weeks.
- Full weight bearing was started after fracture union which was determined by disappearance or obliteration of major fracture lines in anteroposterior and lateral view X rays.

FUNCTIONAL ASSESSMENT

- Functional assessment was done using Knee Scoring System devised by the hospital for special surgery.

KNEE SCORING SYSTEM BY THE HOSPITAL FOR SPECIAL SURGERY

Pain -30 points	
While walking	
None	15
Mild	10
Moderate	5
Severe	0
At Rest	
None	15

Function-22points	
A)**Walking** and Standing UNLIMITED	12
5-10 blocks walking/standing 30 MIN	10
1-5 Blocks walking/standing 15-30 MIN	8
LESS THAN 1 Block/standing <15 Min	4
Cannot walk	0
B)stairs	
Normal	5
With support	2
C)Transfer	
Normal	5
With support	2

Range of Motion	
120 Degrees	15
110 Degrees	14
100 Degrees	12
90 Degrees	11
80 Degrees	10

Muscle strength -15 points	
Gr-5	15
Gr-4	12
Gr-3	9
Gr-2	6
Gr-1	3
Gr-0	0

Flexion deformity -10 points	
None	10
0-10 Degrees	8
10-20 Degrees	5
>20 Degrees	0

SUBTRACTIONS

- ONE CANE 1
- ONE CRUTCH 2
- TWO CRUTCHES 3
- **ENTENSOR LAG**
- 5 – DEGREES 2
- 10- DEGREES 3
- 15-DEGREES 5
- **DEFORMITY**
- (5 DEG. = 1 POINT)
- VARUS
- VALGUS
- TOTAL SUBTRACTION

KNEE SCORE = (TOTAL POINTS) – (TOTAL SUBTRACTION)

- **EXCELLENT** **85 POINTS OR MORE**
- **GOOD** **70 - 84 POINTS**
- **FAIR** **60 -69 POINTS**
- **POOR** **< 60 POINTS**

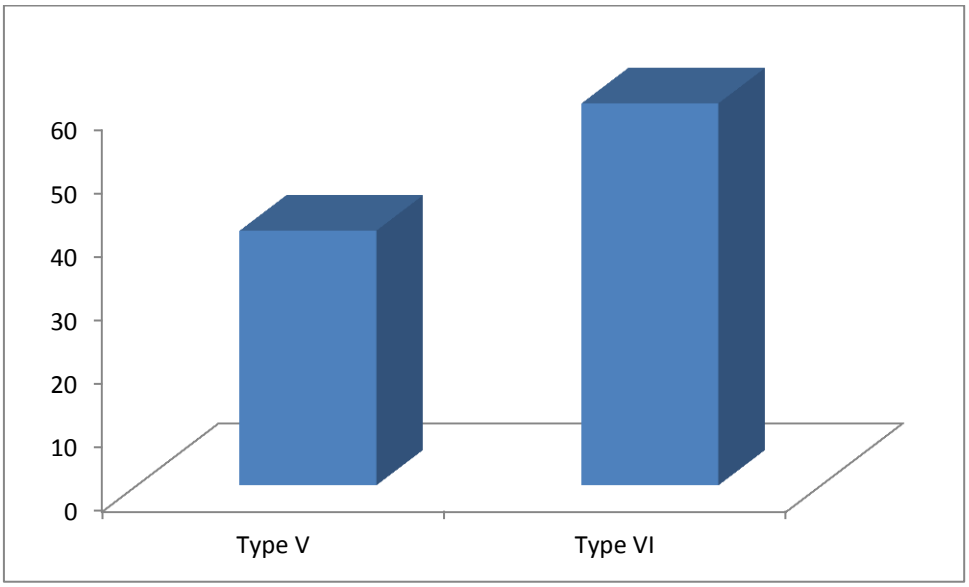
OBSERVATION

- The mean age in our study was 33.4 years.
- In our study males outnumbered females in the ratio of 9:1.
- Road traffic accident was the major cause.
- Old individuals with osteoporotic bones can sustain complex tibial plateau fractures resulting from low energy injuries. We had one such patient in our series who was a 55 year old female.
- Incidence is more on right side – 65% in right side and 35% in left side.
- Of the 20 cases, there was Schatzker type V in 40% and type VI in 60%
- The mean follow up was 9.2 months.

TYPE OF FRACTURE:

Only Schatzker type V and VI were included in the study.

Type of fracture	No. of patients	Percentage
V	8	40
VI	12	60



ASSOCIATED INJURIES

Among 20 patients, four patients had associated injuries.

1) Fracture mandible

2) Contralateral fracture shaft of femur

3) Rib fracture

4) Distal radius fracture

Time of surgery:

The average time duration from day of injury to day of surgery was 8.95 days ranging from 2 to 20 days.

- All patients had either Schatzker type V or type VI tibial plateau fracture
- They underwent a standard anterolateral surgical approach.
- 10 patients underwent open reduction
- 10 patients underwent closed reduction by traction using fracture table
- Lateral locking plate and screws was used in all patients .

COMPLICATIONS

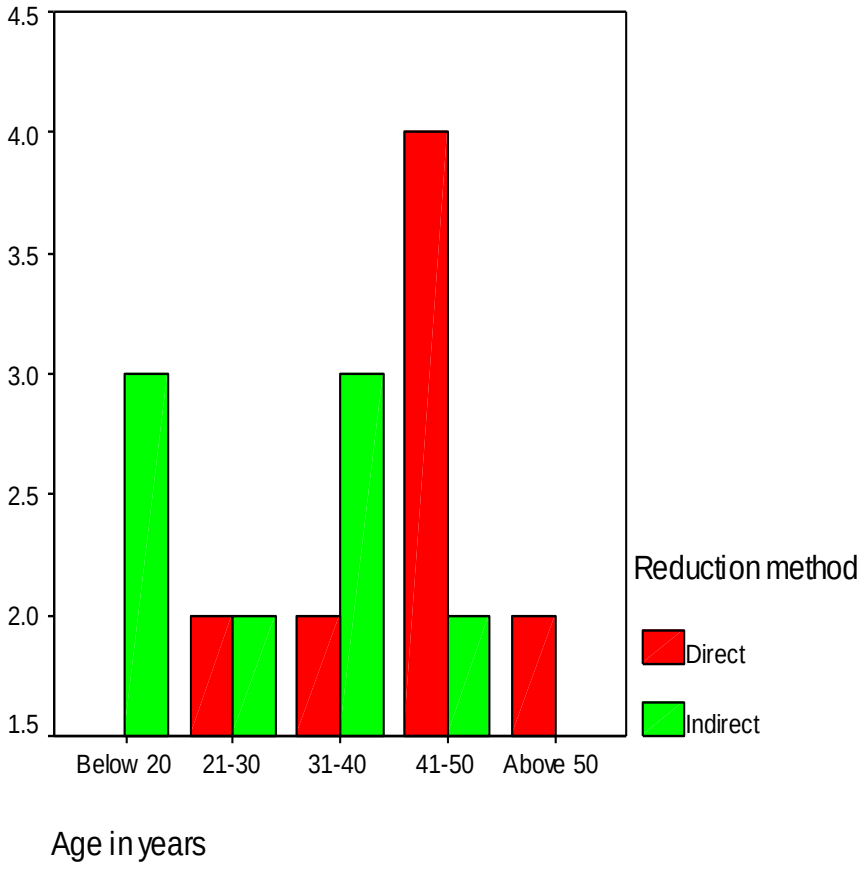
The following complications were noted in our study.

- Knee stiffness
- Infection
- Varus collapse
- Knee pain

RESULTS AND ANALYSIS

Age in years vs Reduction method

Age in years			Reduction method		Total
			Direct	Indirect	
	Below 20	Count	0	3	3
	21-30	Count	2	2	4
	31-40	Count	2	3	5
	41-50	Count	4	2	6
	Above 50	Count	2	0	2
Total		Count	10	10	20

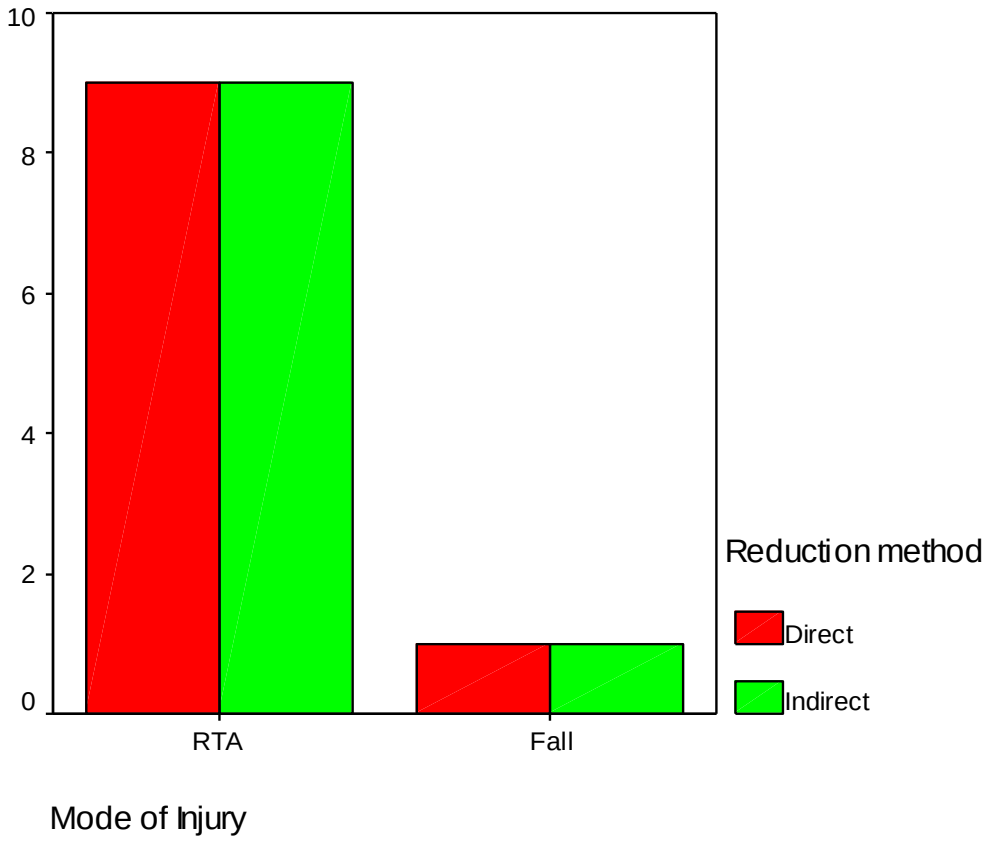


Sex vs Reduction method

Sex			Reduction method		Total
			Direct	Indirect	
1	Male	Count	8	10	18
2	Female	Count	2	0	2
Total		Count	10	10	20

Mode of Injury vs Reduction method

Mode of Injury			Reduction method		Total
			Direct	Indirect	
1	RTA	Count	9	9	18
2	Fall	Count	1	1	2
Total		Count	10	10	20

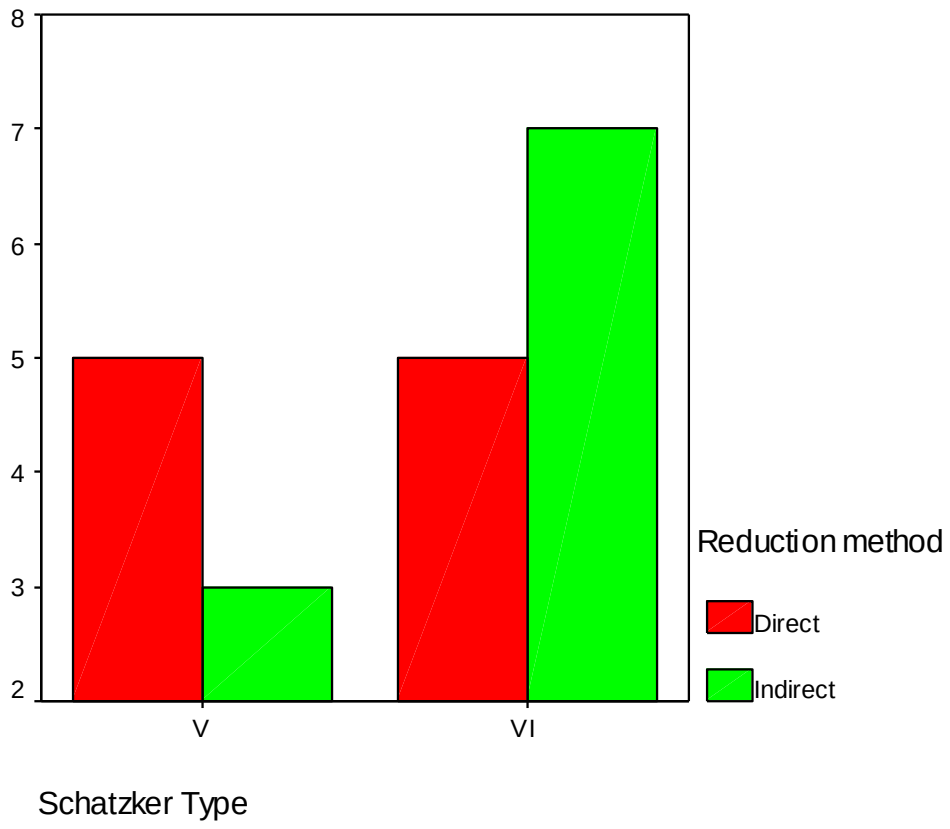


Side vs Reduction method

Side			Reduction method		Total
			Direct	Indirect	
1	Left	Count	5	2	7
2	Right	Count	5	8	13
Total		Count	10	10	20

Schatzker Type vs Reduction method

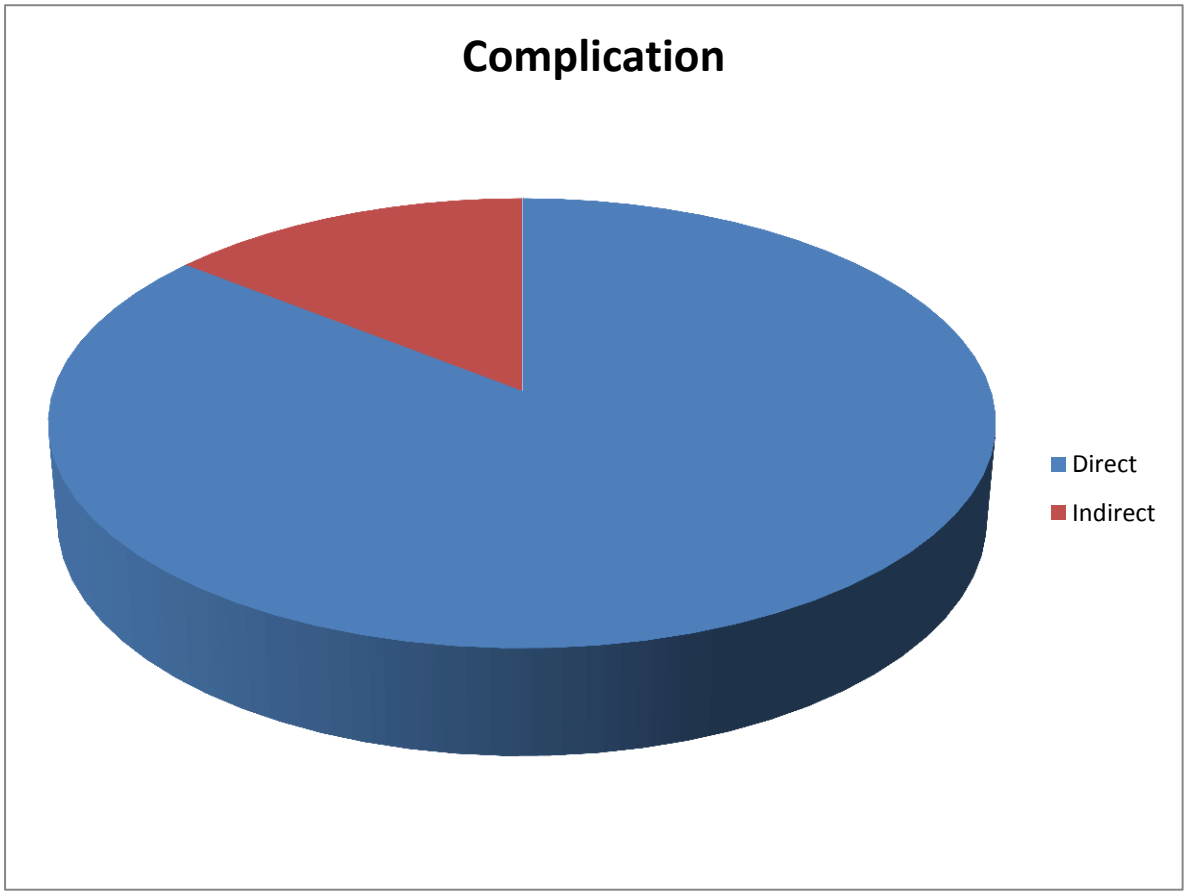
Schatzker Type			Reduction method		
			Direct	Indirect	Total
1	V	Count	5	3	8
2	VI	Count	5	7	12
Total		Count	10	10	20

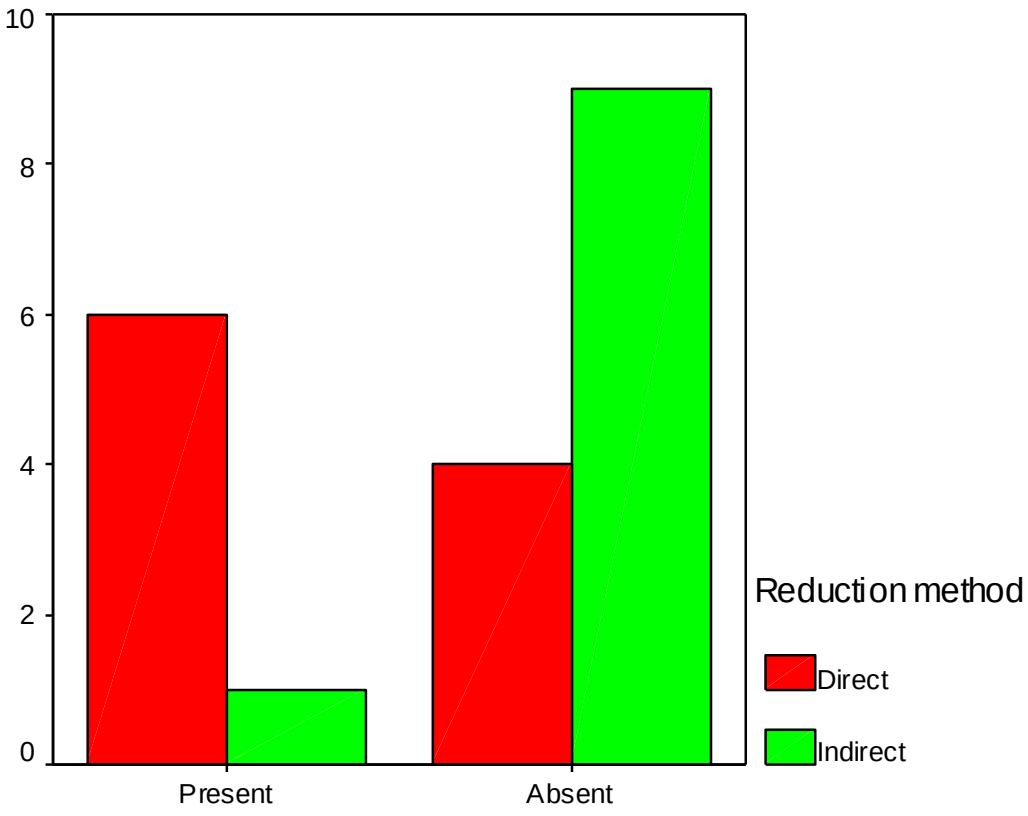


Complication vs Reduction method

Complication		Reduction method		Total	P value
		Direct	Indirect		
Present	Count	6	1	7	0.019
Absent	Count	4	9	13	
Total	Count	10	10	20	

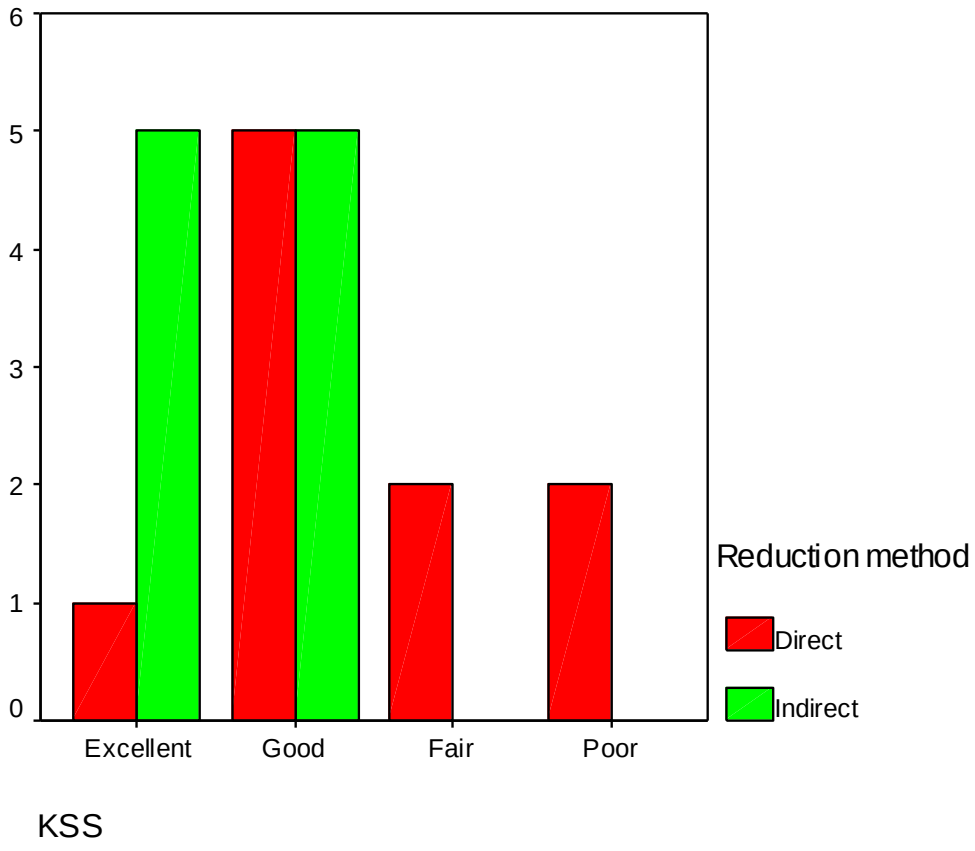
The p value is < 0.05 . It is statistically significant.




10
8
6
4
2
0
Present
Absent
Complication
Reduction method
Direct
Indirect

KSS vs Reduction method

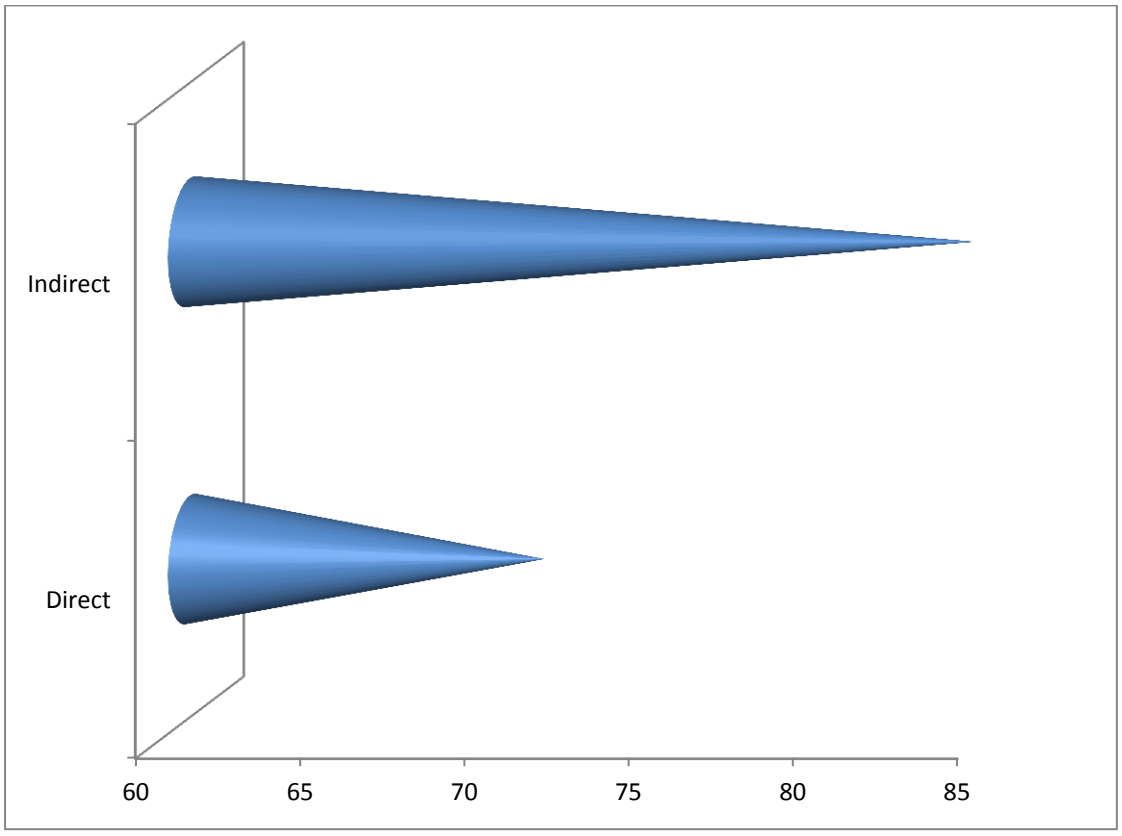
Knee Scoring System			Reduction method		Total
			Direct	Indirect	
(KSS)	Excellent	Count	1	5	6
	Good	Count	5	5	10
	Fair	Count	2	0	2
	Poor	Count	2	0	2
Total		Count	10	10	20



Knee Scoring System

Mode of Reduction	No. of Patients	Average KSS	Grading			
			Excellent	Good	Fair	Poor
Direct	10	70.8	1	5	2	2
Indirect	10	83.9	5	5	0	0

Independent T test was used . The P value for Knee Scoring System (KSS) is 0.001 . **This result is statistically significant as p < 0.05**.

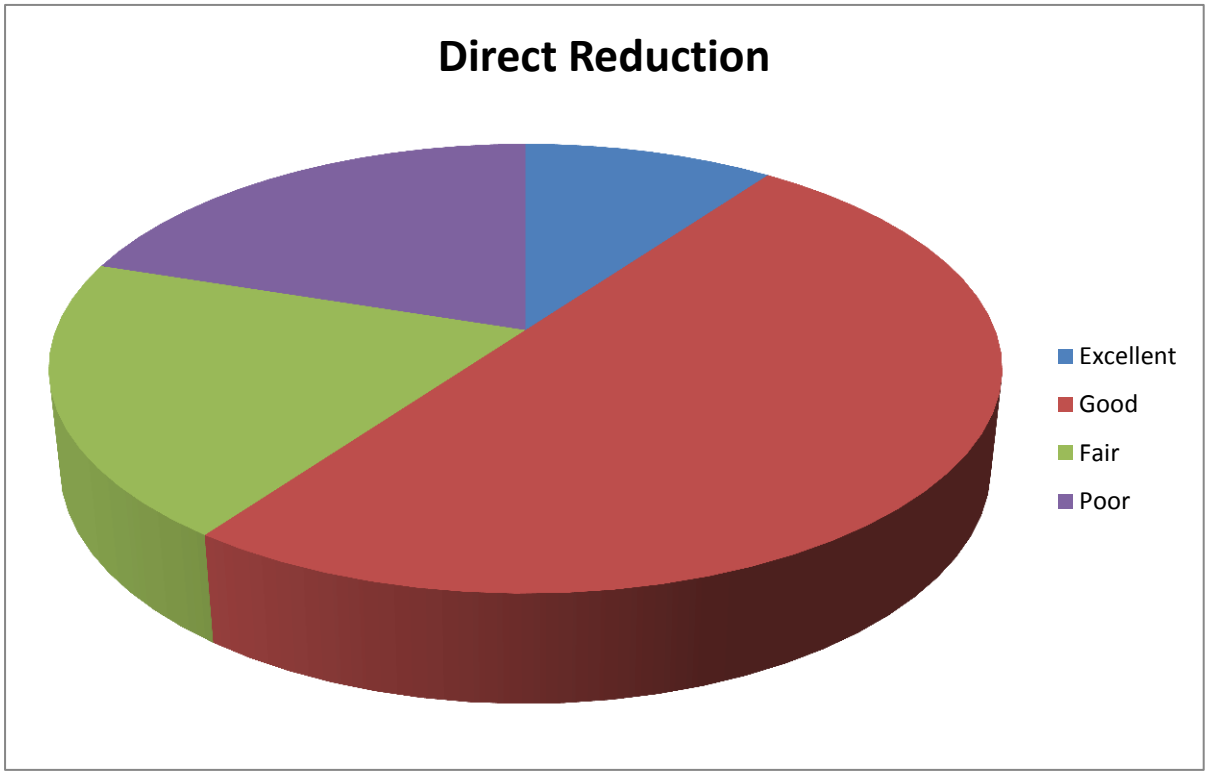


Functional analysis was done using Knee Scoring System, which is a clinical scoring system filled by the surgeon.

AGE WISE FUNCTIONAL SCORING

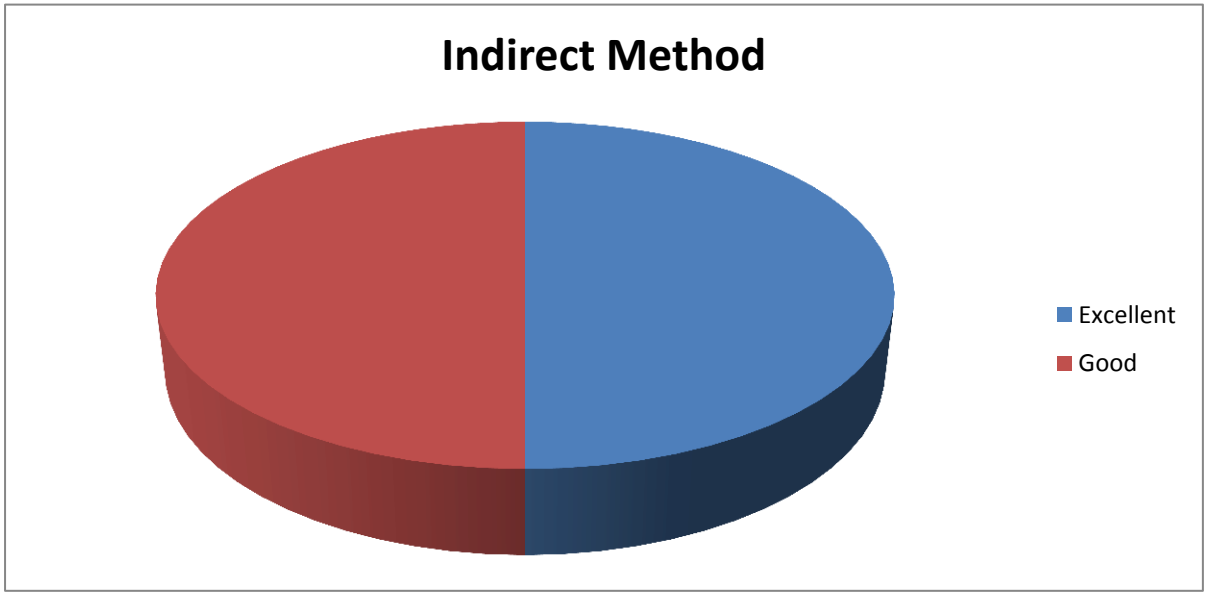
i. Direct Method of Reduction

S.No.	Age group	No.of patients	Average Knee Society	Grading			
				Excellent	Good	Fair	Poor
1	18-30	2	80.5	1	1	-	-
2	31-40	2	66.5	-	-	2	-
3	41-50	4	75.25	-	4	-	-
4	51-60	2	56.5	-	-	-	2



ii. Indirect Method of Reduction

S.No	Age group	No. of patients	Average Knee Society Score	Grading			
				Excellent	Good	Fair	Poor
1	18-30	5	83.6	2	3	-	-
2	31-40	3	84.3	2	1	-	-
3	41-50	2	84	1	1	-	-
4	51-60	0	-	-	-	-	-



Among direct reduction group, 1 patient had excellent result, 5 patients had good result, 2 patients had fair result and 2 patients had poor result.

Among indirect reduction group, 5 patients had excellent result, 5 patients had good result.

	Excellent/Good	Fair/Poor	Marginal Row Totals
Direct Reduction	6	4	10
Indirect Reduction	10	0	10
Marginal Column Totals	16	4	20 (Grand Total)

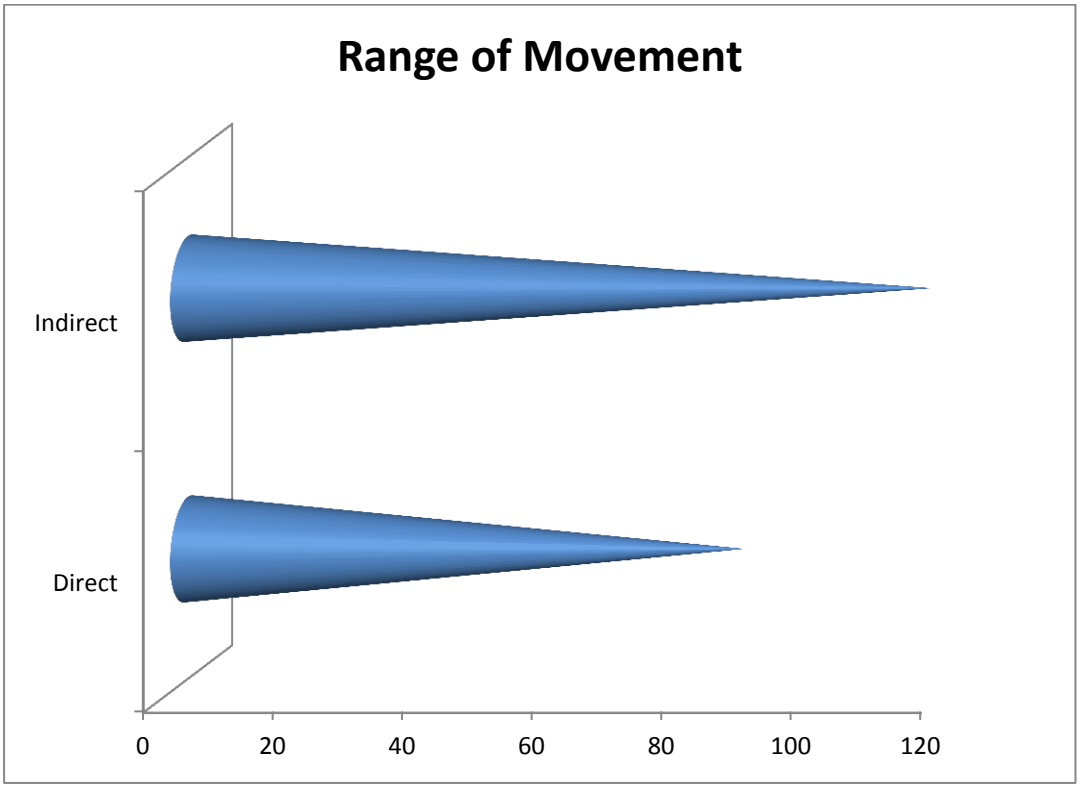
.

Range of movements

The mean range of knee movement for patients who underwent direct reduction was observed as 86° and for patients who underwent indirect reduction was 115°.

	Reduction method	N	Mean	Std. Deviation	P value
ROM (degrees)	Direct	10	86.00	16.465	<0.001
	Indirect	10	115.00	8.498	

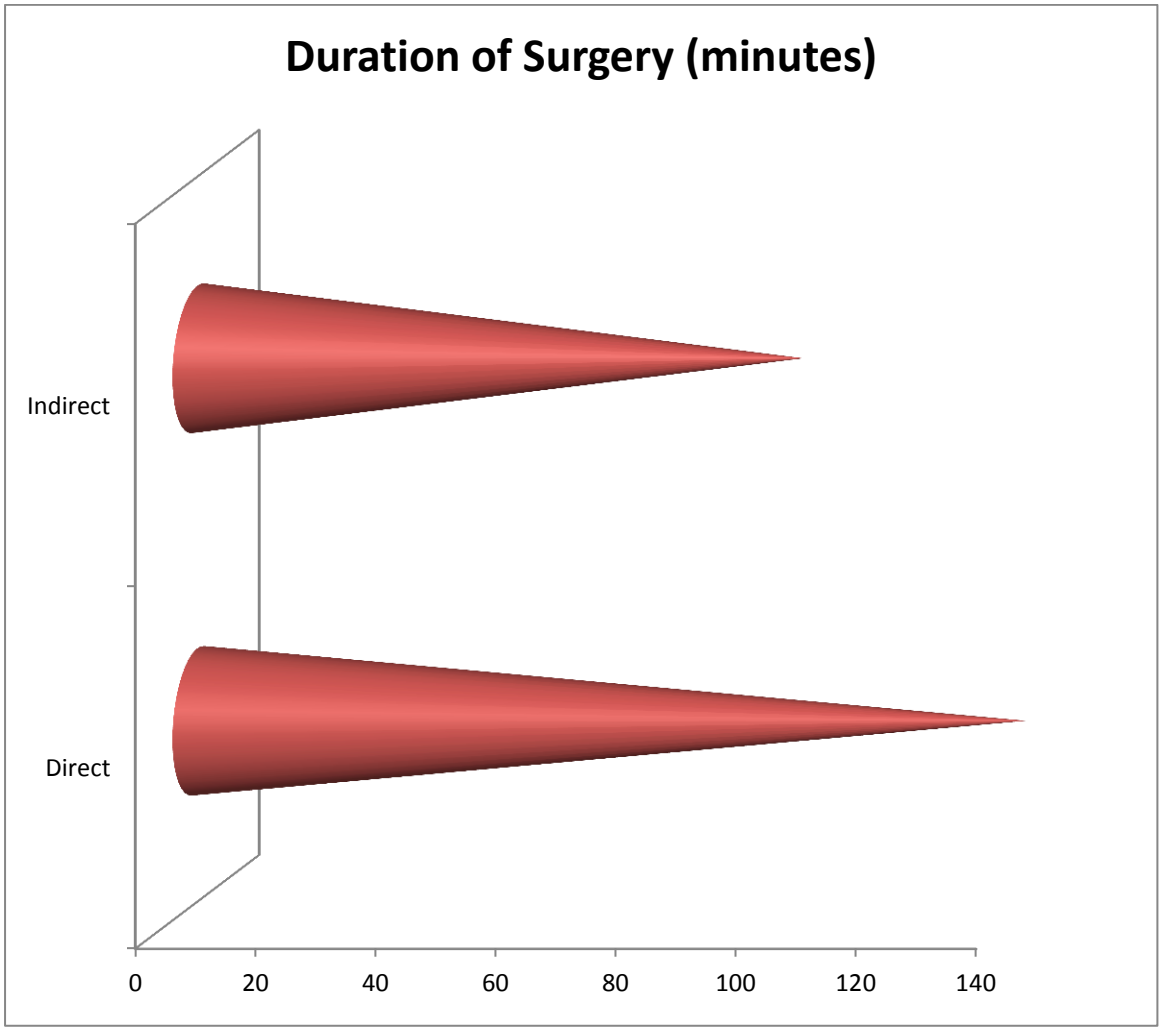
By Independent T test the p value is <0.001 . It is statistically significant.



Duration of Surgery

	Reduction method	N	Mean	Std. Deviation	P value
Duration of Surgery (minutes)	Direct	10	138.00	14.757	<0.001
	Indirect	10	101.00	9.944	

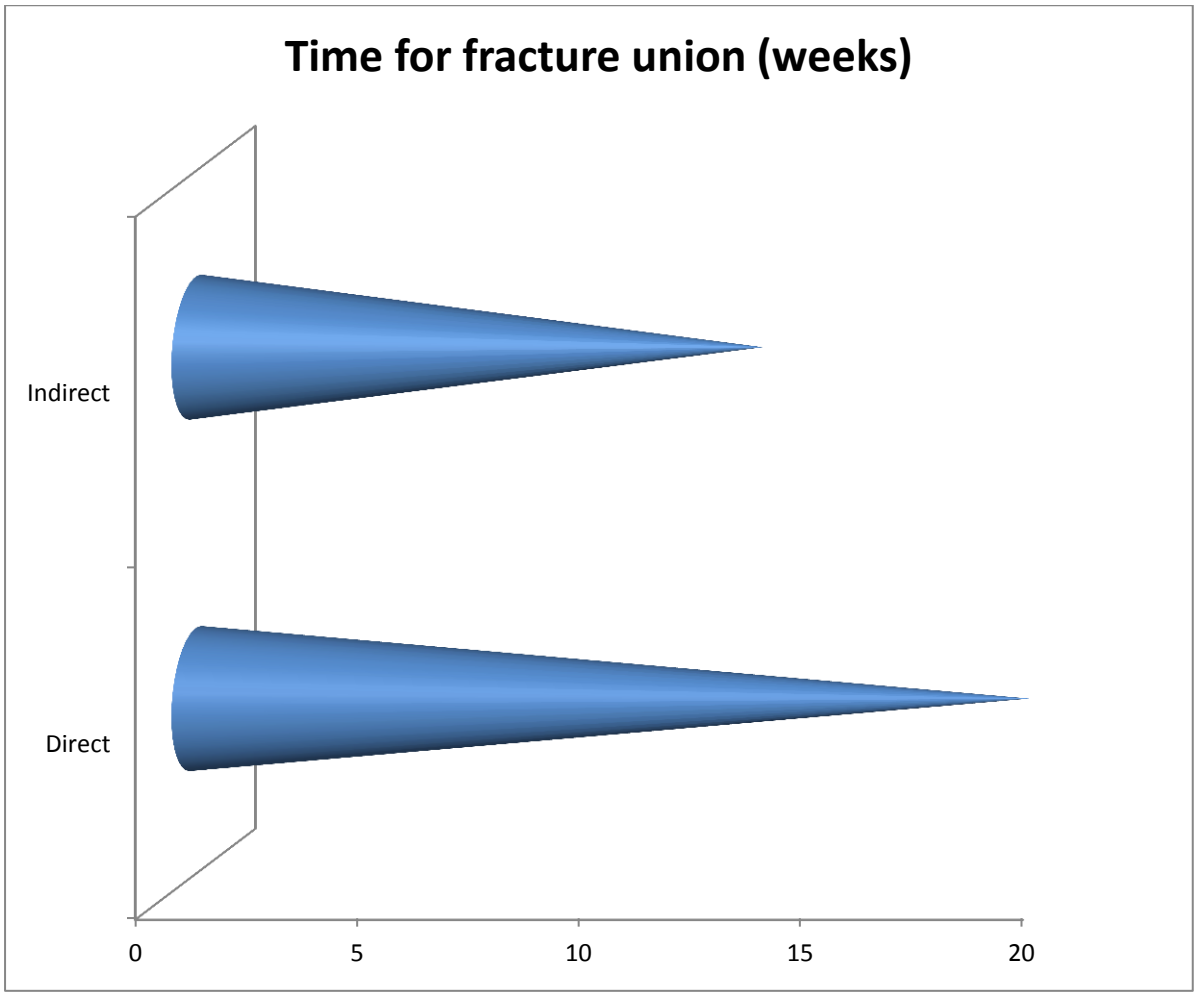
By Independent T test the p value is <0.001. It is statistically significant.



Time for Fracture Union

	Reduction method	N	Mean	Std. Deviation	P value
Time for union (weeks)	Direct	10	18.80	2.700	<0.001
	Indirect	10	12.80	1.687	

By Independent T test the p value is <0.001 . It is statistically significant.



DISCUSSION

Treatment of tibial plateau fractures is a very challenging entity for the surgeon. Road traffic accidents are increasing day by day resulting in high energy injuries. These contribute to the rising incidence of complex proximal tibial fractures presenting to the healthcare provider. Elderly patients with osteoporotic bones sustain complex tibial plateau fractures due to low energy injuries such as domestic falls.

The aim of the treatment is to provide the patient a painless, mobile joint and it needs a very strong technical knowledge and surgical expertise. Good surgical techniques and implants are essential for accurate articular reduction.

The initial disrepute of bicolumn fixation of complex tibial plateau fractures owes itself to poor surgical technique practiced earlier on. The use of a single midline incision and extreme soft tissue handling led onto a high incidence of wound breakdown and infection and put the orthopaedic fraternity on guard regarding bicolumn fixation [5,6,7]. The advent of locking plates shifted the spectrum towards isolated lateral plating using locking compression plates and stabilizing medial fragment through screws passed via the locking plate [13,18.]

Gosling et al.[50] published the results of their study comparing the biomechanical stability afforded by lateral locking plate and bicolumn non

locked plates. They concluded that both fixation techniques have a high resistance to vertical subsidence even with loads exceeding the average body weight. No statistically significant difference was seen between the two methods of fixation. Several studies have published the superiority of locking plates in proximal tibial fractures [13,18] . There has been a huge development in the field of locking plates and precontoured plates.

Indirect or closed reduction technique minimizes soft tissue trauma since it allows biological fracture fixation by the minimally invasive method. Several studies have reported low complications and early rehabilitation by this method.

In our study, males outnumbered females in the ratio of 9:1. This is explained by the more active lifestyle of males and hence more chances of road traffic accidents. This is in accordance with the series of 14 patients reported by Eggli et al., in which 10 were male and 4 female[40]. But in the study of Lee et[32] al there were 21 males and 24 females.

SEX DISTRIBUTION

Study	**Total no. of patients**	**No. of males**	**No. of females**
Eggli et al	14	10	4
Lee et al	45	21	24
Walia et al [26]	50	45	5
Our study	20	18	2

The mean age of patients in our study was 33.4 yrs (range 19 to 55 yrs).

Road traffic accidents were the cause of injury in all patients. Right side fractures are more common than left.

Bone grafting was not done in any of our cases.

The mean follow up in our study was 9.2 months.

Indirect reduction group had 5 excellent scores and 5 good scores.

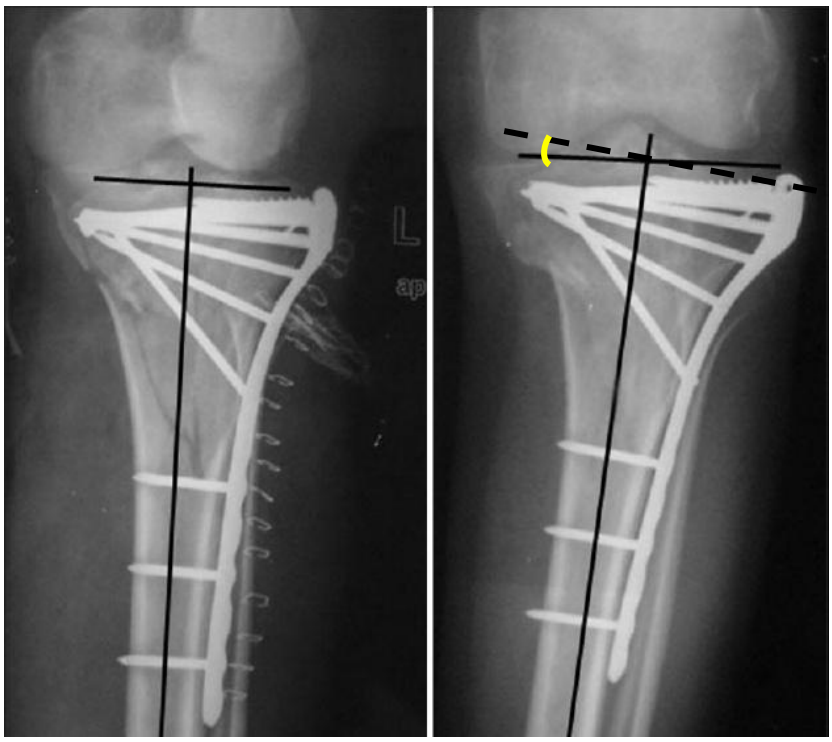
Direct reduction group had 1 excellent , 4 good , 2 fair and 2 poor scores.

We found statistically significant difference in duration of surgery, time for fracture union, range of knee movements, functional outcome and complication rate between the open and closed reduction group. The mean time to union was 12.8 weeks in closed reduction group and 18.8 weeks in open reduction group.

The complication rate was higher in the open reduction group.

- Knee stiffness and flexion less than 90 degree were noted in 4 patients in open reduction group. Range of flexion in these patients is 0° to 60° in 2 patients and 0° to 80° in 2 patients.
- Wound infection was noted in two patients (10%) and were treated with antibiotics and debridement. This is comparable to Mohd Ali Tahririan et al[38] study, in which infection rate was 14.6%


- Knee pain was observed in 4 of twenty patients. 3 patients from open reduction group and 1 from closed reduction group.
- Varus collapse of 8° was noted in 1 patient in the open reduction group.



CONCLUSION

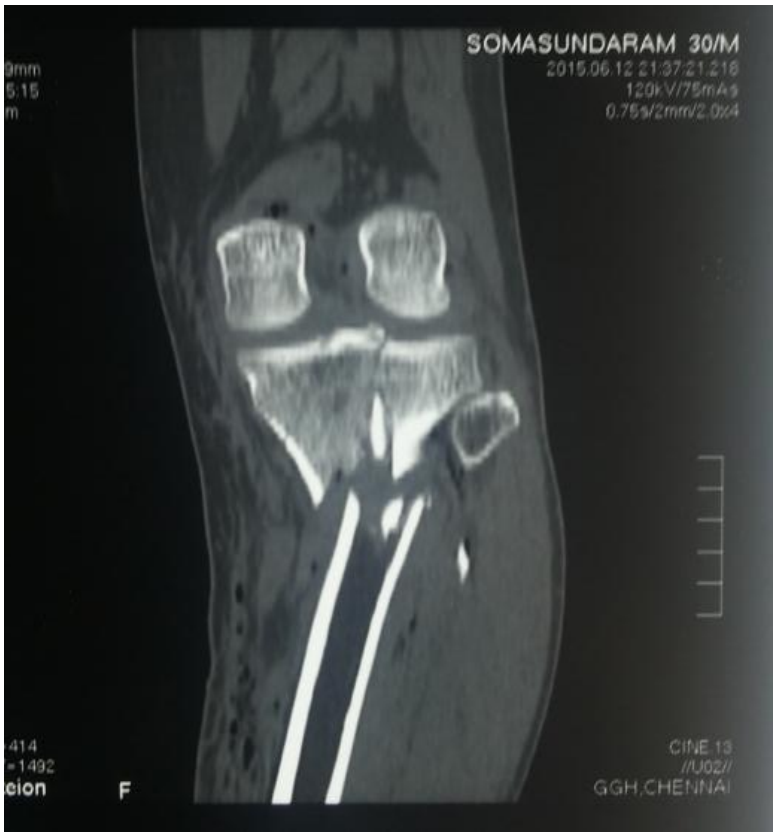
- There is decreased surgical trauma , less duration of surgery and thereby reduced blood loss in closed reduction group.
- The range of knee movement is better with closed reduction group.
- Fracture union occurs early with closed reduction group and thereby early weight bearing and early return to function in this group.
- The functional outcome assessed using Knee Scoring System shows better functional outcome with closed reduction group in the aspects of pain, range of knee movements, functions like standing, walking and climbing stairs and knee stability.
- Complication rate is much lower in closed reduction group. There has not been any knee stiffness or infection in this group.
- So, from this study it can be concluded that when compared to open reduction , closed reduction technique is a better and effective method for achieving good to excellent results providing almost full range of motion and early return to function in the treatment of high energy type V and type VI Schatzker tibial plateau fractures.

CASE ILLUSTRATION

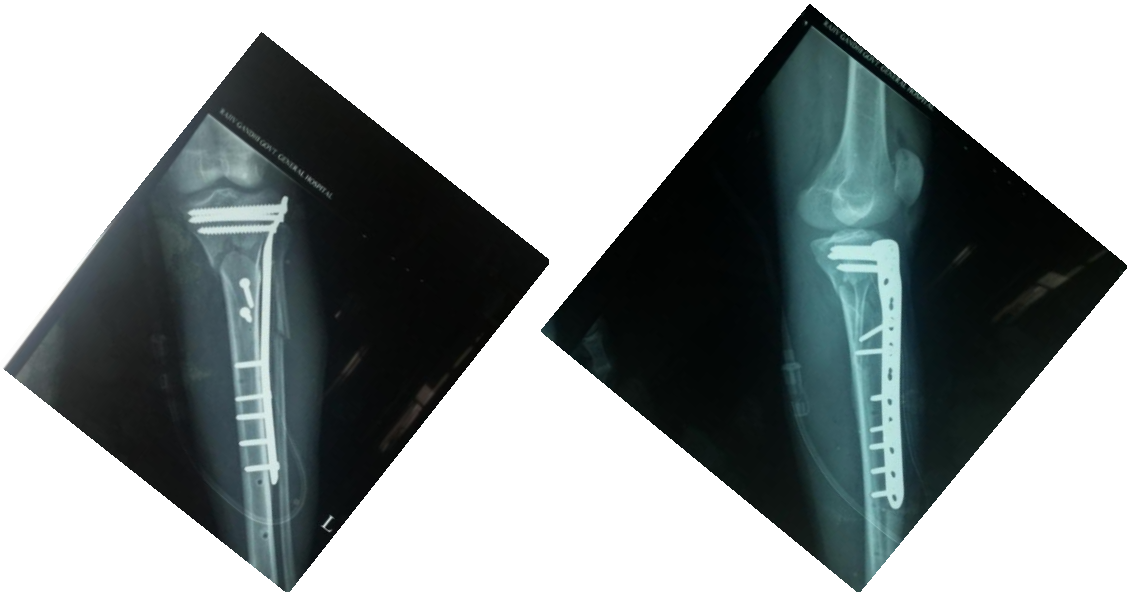
Case 1

Name	Somasundaram
Age/Sex	30 years/Male
Mode of Injury	RTA
Side injured	Left
Schatzker type	Type VI
Time Interval between injury and surgery	6 days
Reduction Method	Direct
Post-op period	Uneventful
Knee mobilization	7 days
Partial weight bearing	12 weeks
Full weight bearing	16 weeks
At follow-up	6 months
Range of movements	0° to 100°
Knee Society Score	85
KSS Result	Excellent

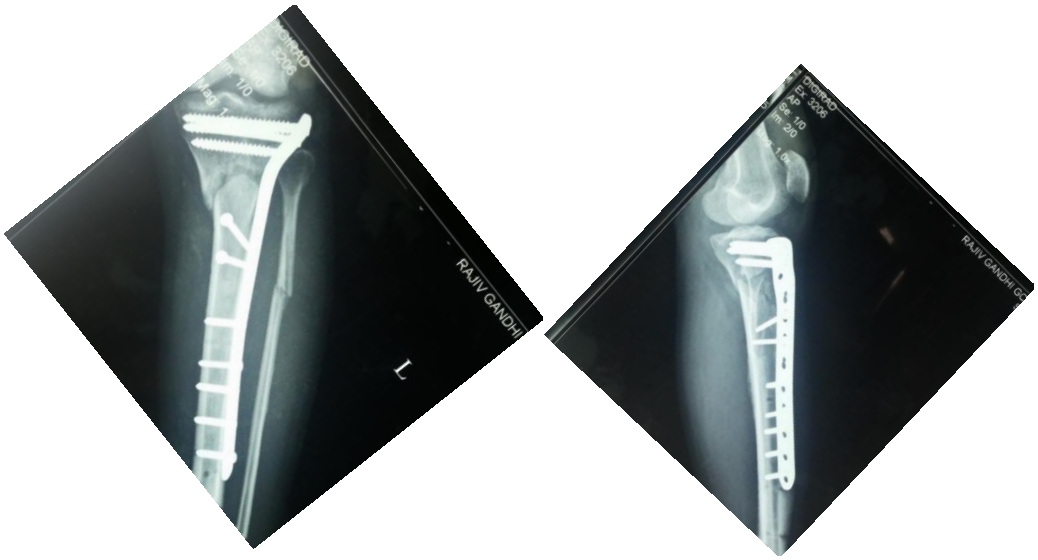
Pre-Operative



Immediate Post-Op



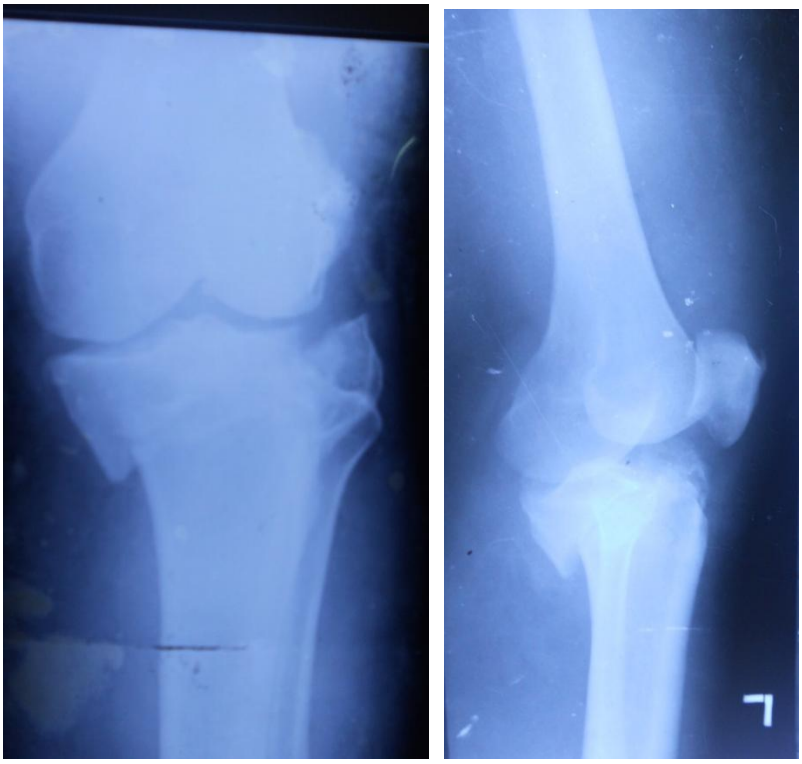
6 months follow up



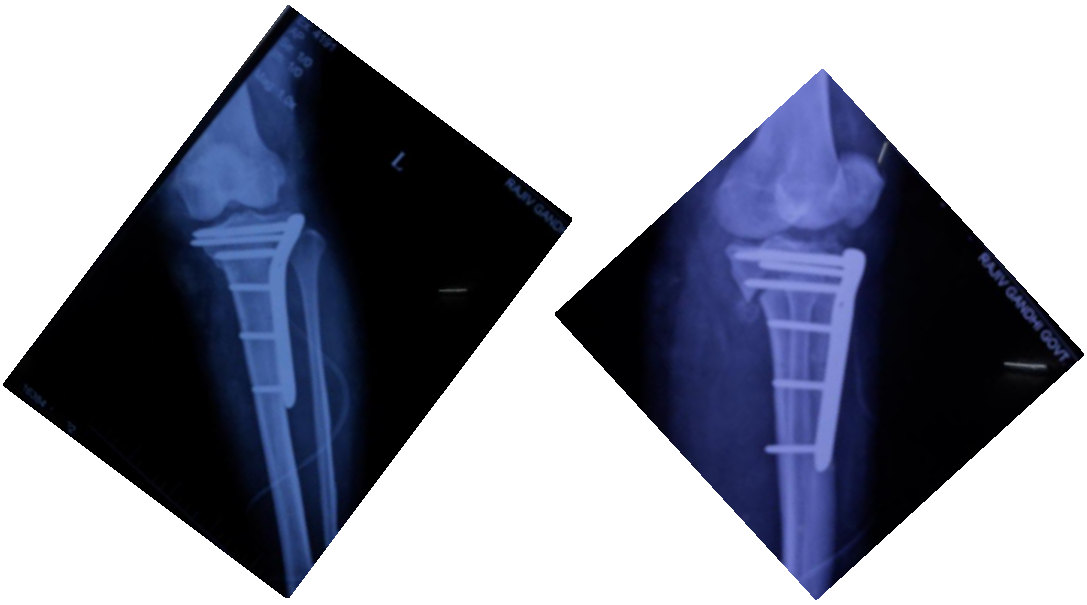
Case 2

Name	Anbu
Age	49
Sex	Female
Mode of Injury	RTA
Side injured	Right
Schatzker type	Type V
Time Interval between injury and surgery	11 days
Reduction method	Direct
Post-op period	Uneventful
Knee mobilization	8 days
Partial weight bearing	12 weeks
Full weight bearing	16 weeks
At follow-up	15 months
Range of movements	0° to 100°
Knee Society Score	72
KSS Result	Good

Pre-Operative



Immediate Post-Op

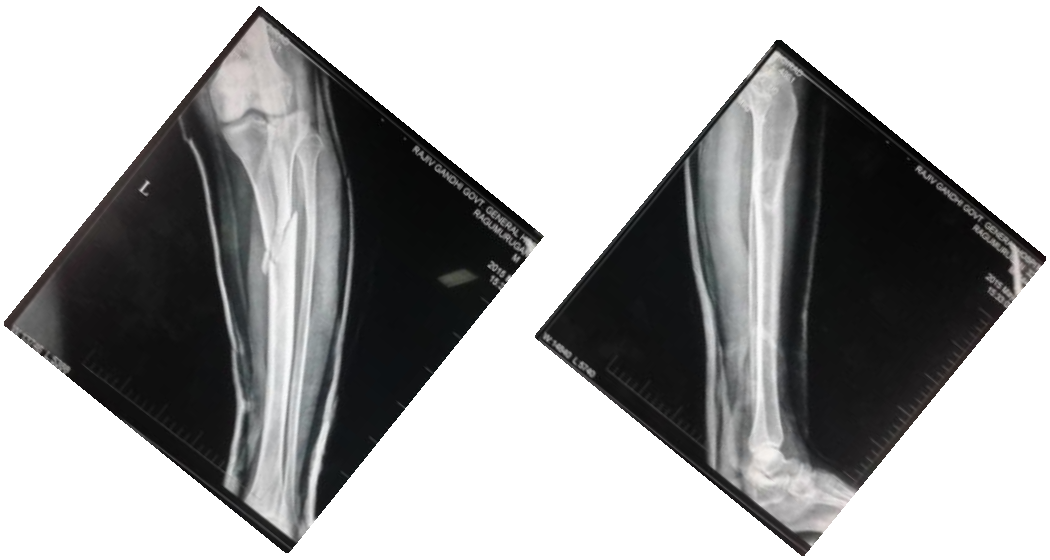


15 months follow up

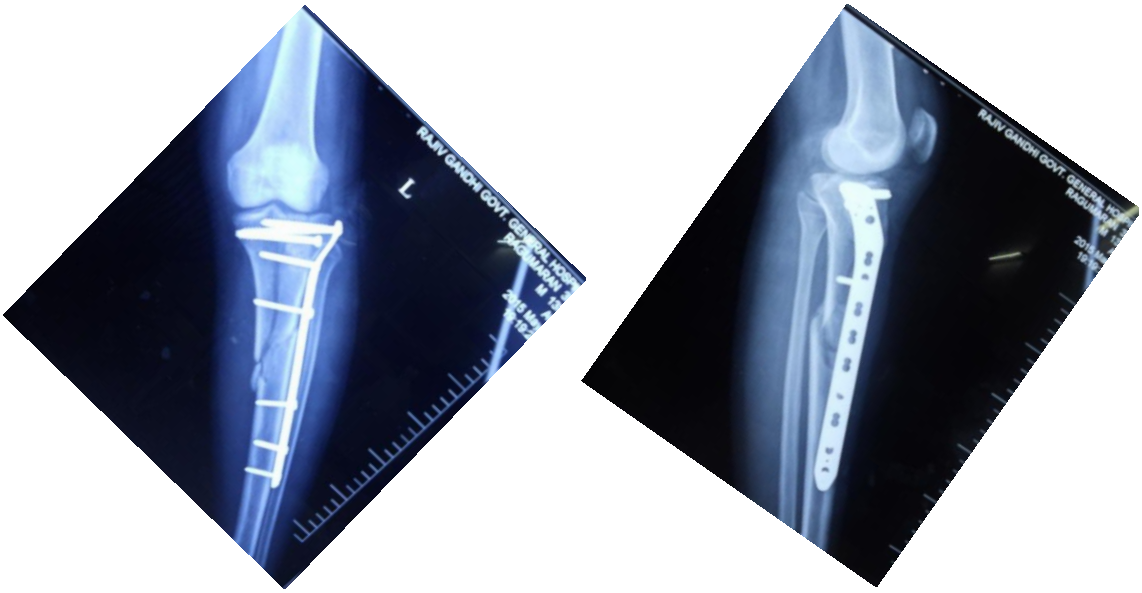
Case 3

Name	Raghumaran
Age	32
Sex	Male
Mode of Injury	RTA
Side injured	Left
Schatzker type	Type VI
Time Interval between injury and surgery	7 days
Reduction Method	Closed
Post-op period	Uneventful
Knee mobilization	8 days
Partial weight bearing	12 weeks
Full weight bearing	14 weeks
Follow-up	8 months
Range of movements	0° to 120°
Knee Society Score	88
KSS Result	Excellent

Preoperative



Immediate postoperative



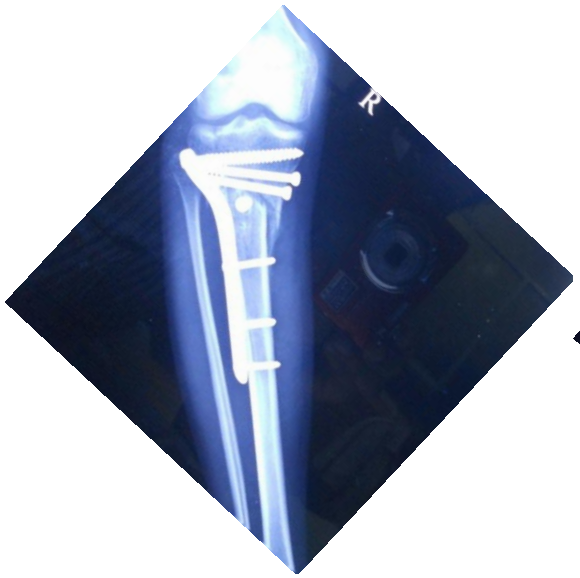
8 months follow up

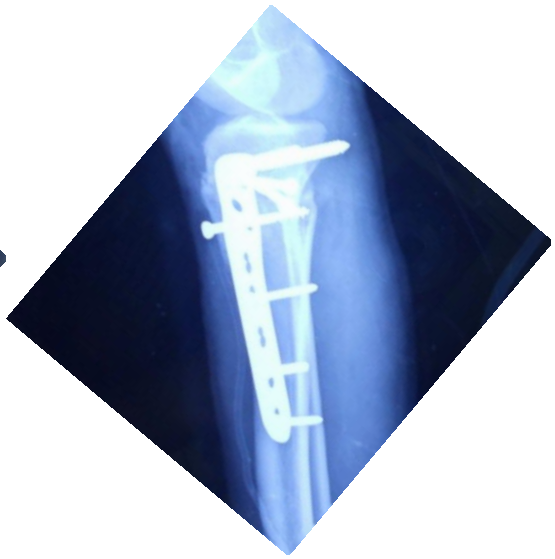
Case 4

Name	Harikumar
Age	19
Sex	Male
Mode of Injury	RTA
Side injured	Right
Schatzker type	Schatzker Type VI
Time Interval between injury and surgery	9 days
Procedure	Closed
Post-op period	Uneventful
Knee mobilization	9 days
Partial weight bearing	12 weeks
Full weight bearing	14 weeks
At follow-up	8 months
Range of movements	0° to 130°
Knee Society Score	86
KSS Result	Excellent

Pre-Operative

Immediate Post Operative





8 months follow-up

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LIST OF ABBREVIATIONS

ACL – Anterior Cruciate Ligament

A.O – Arbeitsgemeinschaft für Osteosynthesefragen

ASIF – Association for the Study of Internal Fixation

BG – Bone Grafting

DCP – Dynamic Compression Plating

KSS – Knee Society Score

NWB – Non Weight Bearing

PCL – Posterior Cruciate Ligament

ROM – Range of Motion

PATIENT EVALUATION PROFORMA

PRE-OPERATIVE

Name _____

Age _____ Sex ☐ Male ☐ Female

IP Number _____ Admission Date _____

Time from Injury to Surgery _____ Injury Mode _____

Diagnosis	
Associated injuries	
Co-morbidities	
X-Ray finding	
CT finding	
Classification	
Distal neurovascular status	

INTRA-OPERATIVE

Position	
Anesthesia	
Approach	
Procedure done	
Reduction Method	
Plate placement	
Plates used	
Blood loss	
Duration of surgery	
Post-Op immobilization	

POST-OPERATIVE	
Drain collection	
Day of drain removal	
Postoperative x ray	
Wound status at discharge	
Suture removal	
IV antibiotics	
Oral antibiotics	
Associated injury treatment	
Distal neurovascular status	

FOLLOW-UP		
Date	Visit number	
Postoperative month		
Wound status		
X ray		
Weight bearing		
Knee society score		
1.) Pain		
2.) Range of Motion		
3.) Stability	☐ Anteroposterior	☐ Mediolateral
4.) Deductions		
	Flexion Contracture	
	Extension Lag	
	Alignment	

MASTER CHART

S. No.	Name	Age	Sex	I.P.No	Mode of Injury	Side	Associated injuries	Schatzker Type	Reduction method	Time for union (weeks)	Knee score	Complication	Follow up (Months)	ROM (degrees)	KSS Result	Duration of Surgery (min)
1	Somasundaram	30	M	62361	RTA	L	-Nil-	VI	Direct	16	85	-Nil-	6	100	Excellent	150
2	Anbu	49	F	47093	RTA	R	-Nil-	V	Direct	16	72	Knee pain	15	110	Good	140
3	Senthil	23	M	23282	RTA	R	Lt Femur #	VI	Direct	16	76	-Nil-	6	100	Good	160
4	Suresh	41	M	18986	RTA	L	-Nil-	V	Direct	20	79	Pain	6	90	Good	150
5	Mathiyalagan	45	M	51533	RTA	R	-Nil-	VI	Direct	20	74	-Nil-	16	90	Good	130
6	Palani	54	M	33475	RTA	L	# Lt mandible	V	Direct	20	58	Infection, Varus Collapse, ↓ ROM	17	60	Poor	120
7	Damodaran	45	M	72172	RTA	R	-Nil-	V	Direct	16	76	-Nil-	6	90	Good	120
8	Muniyammal	55	F	42067	Fall	L	-Nil-	VI	Direct	20	55	Knee Stiffness, Pain	15	60	Poor	140
9	Palani	36	M	8403	RTA	L	-Nil-	V	Direct	24	65	Infection, ↓ ROM	7	80	Fair	150
10	Kadhar	40	M	24207	RTA	R	-Nil-	VI	Direct	20	68	↓ ROM	17	80	Fair	120

S. No.	Name	Age	Sex	I.P.No	Mode of Injury	Side	Associated injuries	Schatzker Type	Reduction method	Time for union (weeks)	Knee score	Complication	Follow up (Months)	ROM (degrees)	KSS Result	Duration of Surgery (min)
11	Raghumaran	32	M	34992	RTA	L	-Nil-	VI	Indirect	12	88	-Nil-	8	120	Excellent	90
12	Hari Kumar	19	M	41786	RTA	R	-Nil-	VI	Indirect	12	86	-Nil-	8	130	Excellent	100
13	Baskar	34	M	26476	RTA	R	Rt 2,3 #	VI	Indirect	12	85	-Nil-	7	120	Excellent	100
14	Gowtham	27	M	67205	RTA	R	-Nil-	VI	Indirect	12	78	Pain	6	110	Good	110
15	Joseph	45	M	91772	RTA	R	-Nil-	V	Indirect	12	82	-Nil-	6	120	Good	90
16	Suresh	36	M	354999	RTA	R	-Nil-	V	Indirect	16	80	-Nil-	8	110	Good	100
17	Raja	20	M	65715	RTA	R	-Nil-	VI	Indirect	12	84	-Nil-	6	120	Good	90
18	Sampath	47	M	22205	Fall	R	Right Distal Radius #	VI	Indirect	16	86	-Nil-	6	110	Excellent	100
19	Sakthivel	26	M	132345	RTA	R	-Nil-	VI	Indirect	12	88	-Nil-	9	110	Excellent	110
20	Pugalendhi	19	M	18	RTA	L	-Nil-	V	Indirect	12	82	-Nil-	9	100	Good	120

PATIENT CONSENT FORM

Study Detail	:	**"A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND CLOSED REDUCTION IN INTERNAL FIXATION OF PROXIMAL TIBIA FRACTURES"**
Study Centre	:	Rajiv GandhiGovernment GeneralHospital, Chennai.
Patient's Name	:	
Patient's Age	:	
Identification Number	:	

Patient may check (√) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ☐

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ☐

c) I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ☐

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms. ☐

e) I hereby consent to participate in this study. ☐

f) I hereby give permission to undergo detailed clinical examination, Radiographs & blood investigations as required. ☐

Signature/thumb impression	Signature of Investigator
Patient's Name and Address:	Investigator's Name: **Dr.VINOTH.S**

INFORMATION SHEET

Principle Investigator's Name :

Participant Name :

We are conducting **"A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND CLOSED REDUCTION IN INTERNAL FIXATION OF PROXIMAL TIBIA FRACTURES"** among patients attending the Institute of Orthopaedics& Traumatology, Rajiv Gandhi Government General Hospital, Chennai .

The purpose of this study is to evaluate and analyse the radiological and functional outcome of proximal tibia fracture treated with internal fixation by open and closed methods.We are selecting certain patients and if you are found eligible, we may use your radiographs, Computarised Tomograms to evaluate the outcome of the treatment which in any way do not affect your final management.

All the procedures are free of cost and there will not be any side effects.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator | Signature of Participant

Date :
Place :

ஆராய்ச்சி ஒப்புதல் படிவம்

ஆராய்ச்சியின் தலைப்பு

முற்பகுதி டிபியா எலும்பு (கால் எலும்பு) முறிவிற்கான அறுவை சிகிச்சை முறைகளை ஒப்பிடும் ஆய்வு

ஆய்வு நிலையம் : முடநீக்கியல் மற்றும் விபத்தியல் துறை,
சென்னை மருத்துவக் கல்லூரி சென்னை - 3.

பங்கு பெறுபவரின் பெயர் :

உள்நோயாளி எண் :

பங்குபெறுபவர் இதனை (✓) குறிக்கவும்

மேலே குறிப்பிட்டுள்ள மருத்துவ ஆய்வின் விவரங்கள் எனக்கு விளக்கப்பட்டது. என்னுடைய சந்தேகங்களை கேட்கவும், அதற்கான தகுந்த விளக்கங்களை பெறவும் வாய்ப்பளிக்கப்பட்டது. ☐

நான் இவ்வாய்வில் தன்னிச்சையாகதான் பங்கேற்கிறேன். எந்த காரணத்தினாலோ எந்த கட்டத்திலும் எந்த சட்ட சிக்கலுக்கும் உட்படாமல் நான் இவ்வாய்வில் இருந்து விலகி கொள்ளலாம் என்றும் அறிந்து கொண்டேன். ☐

இந்த ஆய்வு சம்பந்தமாகவோ, இதை சார்ந்த மேலும் ஆய்வு மேற்கொள்ளும் போதும் இந்த ஆய்வில் பங்குபெறும் மருத்துவர் என்னுடைய மருத்துவ அறிக்கைகளை பார்ப்பதற்கு என் அனுமதி தேவையில்லை என அறிந்து கொள்கிறேன். நான் ஆய்வில் இருந்து விலகிக் கொண்டாலும் இது பொருந்தும் என அறிகிறேன். ☐

இந்த ஆய்வின் மூலம் கிடைக்கும் தகவல்களையும், பரிசோதனை முடிவுகளையும் மற்றும் சிகிச்சை தொடர்பான தகவல்களையும் மருத்துவர் மேற்கொள்ளும் ஆய்வில் பயன்படுத்திக்கொள்ளவும் அதை பிரசுரிக்கவும் என் முழு மனதுடன் சம்மதிக்கின்றேன். ☐

இந்த ஆய்வில் பங்கு கொள்ள ஒப்புக்கொள்கிறேன். எனக்கு கொடுக்கப்பட்ட அறிவுரைகளின்படி நடந்து கொள்வதுடன், இந்த ஆய்வை மேற்கொள்ளும் மருத்துவ அணிக்கு உண்மையுடன் இருப்பேன் என்று உறுதியளிகிறேன். ☐

இந்த இரு அறுவை சிகிச்சை முறைகளும் ஒப்புக்கொள்ளப்பட்ட முறைகள் என்பதையும் இதனால் உடலுக்கு எந்தவிதமான உபாதைகளும் இருக்காது என்பதை அறிந்துகொண்டு இந்த ஆய்வில் பங்குபெற முழு மனதுடன் சம்மதிக்கிறேன். ☐

பங்கேற்பவரின் கையொப்பம் ..... இடம்..... தேதி.....

இடது கை பெருவிரல் ரேகை

பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....

ஆய்வாளரின் கையொப்பம் ..... இடம்..... தேதி.....

ஆய்வாளரின் பெயர் .....

ஆராய்ச்சி தகவல் தாள்

ஆய்வாளரின் பெயர் : மரு.ச.வினோத்
பங்கேற்பாளரின் பெயர் :

சென்னை ராஜீவ்காந்தி அரசு பொது மருத்துவமனையின் முட நீக்கியல் மற்றும் விபத்தியல் துறையில் "முற்பகுதி டிபியா எலும்பு (கால் எலும்பு) முறிவிற்கான அறுவை சிகிச்சை முறைகளை ஒப்பிடும் ஆய்வு" நடைபெறுகிறது.

நாங்கள் மேற்கொண்டுள்ள ஆராய்ச்சி ஆய்விற்கு உங்களை வரவேற்கிறோம். எங்களுக்கு IEC-யிடம் ஒப்புதல் கிடைத்துள்ளது. நீங்கள் பங்கேற்கும் தகுதியை பூர்த்தி செய்துள்ளதால் உங்களை பங்கேற்குமாறு அழைக்கிறோம். நாங்கள் முழங்கால் மூட்டு மாற்று அறுவை சிகிச்சையின் கருவிகளின் அமைப்பைப் பற்றி ஆராய உள்ளோம்.

இந்த ஆராய்ச்சியின் நோக்கம்

1. முற்பகுதி டிபியா எலும்பு முறிவிற்கான இருவேறு அறுவை சிகிச்சை முறைகளை ஒப்பிடுதல்.
2. அறுவை சிகிச்சைக்குப் பின் முழங்கால் மூட்டின் செயல்திறன் பற்றி ஆராய்தல்.
3. ஊடுகதிர் (எக்ஸ்ரே) மூலம் எலும்பு கூடும் தன்மையை ஆராய்தல்.

ஆய்வின் அமைப்பு

இந்த ஆராய்ச்சியில் பங்கேற்கும் தகுதியை பூர்த்தி செய்தவர்களுக்கு எக்ஸ்ரே மற்றும் சி.டி.ஸ்கேன் எடுக்கப்பட்டு பின் அறுவை சிகிச்சை செய்யப்படும். தேர்வானவர்களை இரண்டு பிரிவினராகப் பிரித்து ஒரு பிரிவினருக்கு எலும்பு முறிந்த பகுதியை அறுவை சிகிச்சை மூலம் திறந்து கருவி (பிளேட்) பொருத்தப்படும். மற்றொரு பிரிவினருக்கு எலும்பு முறிந்த பகுதியை நேரடியாக அறுவை சிகிச்சை மூலம் திறந்து சரிசெய்யாமல் ஊடுகதிர் (எக்ஸ்ரே) கருவியின் உதவியுடன் சரிசெய்து கருவி (பிளேட்) பொருத்தப்படும். அறுவை சிகிச்சைக்குப்பின் மீண்டும் எக்ஸ்ரே எடுக்கப்படும். முழங்கால் மூட்டின் செயல்திறன் மற்றும் எலும்பு கூடும் தன்மை ஆராயப்படும்.

ஆய்வின் நன்மைகள்

இந்த ஆய்வின் மூலம் கருவிகளின் அமைப்பு மற்றும் முழங்கால்களின் செயல்திறன் ஆராயப்படுகின்றது.

ஆய்வின் உபாதைகள்

இந்த ஆய்வில் எந்தவித பின்விளைவுகளும் இல்லை. மேலும் இந்த ஆய்வு மிகவும் பாதுகாப்பானது. தங்களுக்கு இதில் ஒப்புதல் இல்லையென்றால் எப்பொழுது வேண்டுமென்றாலும் ஆய்விலிருந்து விலகிக்கொள்ளலாம்.

மருத்துவ சிகிச்சையின் தகவல்கள் குறித்தல் விவரங்கள்

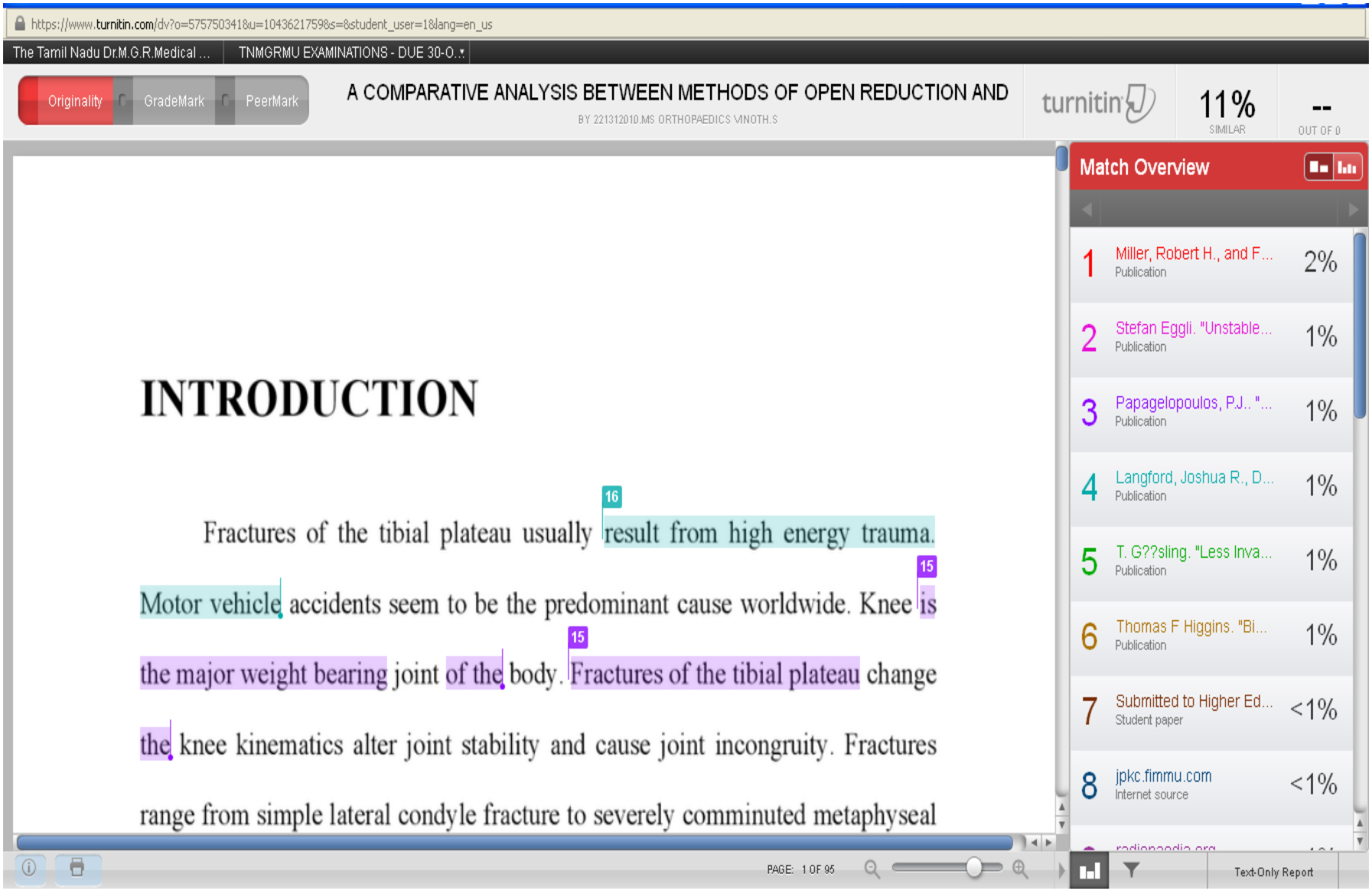
உங்கள் மருத்துவ சிகிச்சை குறித்த தகவல்கள் இரகசியமாக பாதுகாக்கப்படும் (பெயர், மருத்துவ பரிசோதனை முடிவு, மருத்துவ ஆய்வு முடிவு). இந்த தகவல்தாளில் கையெழுத்திடுவதின் மூலம் உங்கள் குறிப்புகளோ, எடுத்துக்கொண்ட சிகிச்சை முறையைப்பற்றியோ ஆய்வாளரோ, எத்திக்கல் கமிட்டி உறுப்பினரோ அறிந்துகொள்ளலாம் என்று சம்மதிக்கிறீர்கள்.

இந்த ஆய்வில் பங்கேற்பது தங்களுடைய விருப்பத்தின் பேரில்தான் இருக்கிறது. எந்த நேரமும் இந்த ஆய்விலிருந்து நீங்கள் பின்வாங்கலாம் என்பதையும் தெரிவித்துக்கொள்கிறோம். இந்த ஆய்வில் நீங்கள் பங்கேற்காவிட்டாலும் வழக்கமான சிகிச்சை தொடர்ந்து பெறலாம்.

இந்த சிறப்பு சிகிச்சையின் முடிவுகளை ஆய்வின்போதோ அல்லது ஆய்வின் முடிவின்போதோ தங்களுக்கு அறிவிப்போம் என்பதை தெரிவித்துக்கொள்கிறோம்.

ஆராய்ச்சியாளர் கையொப்பம் **பங்கேற்பாளர் கையொப்பம்**

நாள் :
இடம் :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A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND
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INTRODUCTION
Fractures of the tibial plateau usually result from high energy trauma. Motor vehicle accidents seem to be the predominant cause worldwide. Knee is the major weight bearing joint of the body. Fractures of the tibial plateau change the knee kinematics alter joint stability and cause joint incongruity. Fractures range from simple lateral condyle fracture to severely comminuted metaphyseal
Match Overview
1 Miller, Robert H., and F... Publication 2%
2 Stefan Eggli. "Unstable... Publication 1%
3 Papagelopoulos, P.J.. "... Publication 1%
4 Langford, Joshua R., D... Publication 1%
5 T. G??sling. "Less Inva... Publication 1%
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Text-Only Report

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No. 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr.Vinoth, S
Post Graduate M.S.(Orthopaedics)
Madras Medical College
Chennai 600 003

Dear Dr.Vinoth S,

The Institutional Ethics Committee has considered your request and approved your study titled **"A comparative analysis between methods of open reduction and closed reduction in internal fixation of proximal tibia fractures" No.30052015.**

The following members of Ethics Committee were present in the meeting held on 12.05.2015 conducted at Madras Medical College, Chennai-3.

1.	Prof.C.Rajendran, M.D.,	: Chairperson
2.	Prof.R.Vimala, M.D., Dean, MMC, Ch-3	: Deputy Chairperson
3.	Prof.B.Kalaiselvi, M.D., Vice-Principal, MMC, Ch-3	: Member Secretary
4.	Prof.B.Vasanthi, M.D., Prof. of Pharmacology, MMC	: Member
5.	Prof.P.Ragumani, M.S., Professor of Surgery, MMC	: Member
6.	Prof.Saraswathy, M.D., Director, Pathology, MMC, Ch-3	: Member
7.	Prof.K.Srinivasagalu, M.D.,Director, I.I.M. MMC, Ch-3	: Member
8.	Thiru S.Rameshkumar, B.Com., MBA	: Lay Person
9.	Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
10.	Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

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INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

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A COMPARATIVE ANALYSIS BETWEEN METHODS OF OPEN REDUCTION AND CLOSED REDUCTION IN INTERNAL FIXATION OF PROXIMAL TIBIA FRACTURES"

INTRODUCTION

Fractures of the tibial plateau usually result from high energy trauma. Motor vehicle accidents seem to be the predominant cause worldwide. Knee is the major weight bearing joint of the body. Fractures of the tibial plateau change the knee kinematics alter joint stability and cause joint incongruity. Fractures range from simple lateral condyle fracture to severe comminuted metaphyseal fractures. These fractures are often associated with severe soft tissue compromise. Hence while treating these fractures, the surgeon takes into consideration many factors like type of fractures, soft tissue and ligamentous injury.